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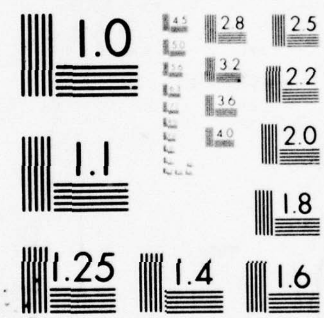

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Special Report 77-3

ESTIMATING HEATING REQUIREMENTS FOR BUILDINGS UNDER CONSTRUCTION IN COLD REGIONS

An Interactive Computer Approach

F. Lawrence Bennett

February 1977

Prepared for
DIRECTORATE OF MILITARY CONSTRUCTION
OFFICE, CHIEF OF ENGINEERS

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
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The paper documents a study that reviewed construction literature to find reports of projects that have been constructed under low-temperature conditions. A survey of Alaskan contractors to determine "cutoff temperatures" and other factors that cause construction work of different types to be suspended is also presented. For both the literature search and the contractor survey, the lowest temperature mentioned was -70°F. The paper also describes a computer program for estimating heat loss and enclosures and heating costs for buildings → next page

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under construction in cold regions. The program is described, a sample program run is presented, and a successful validation effort is summarized.

PREFACE

This report was prepared by Dr. F. Lawrence Bennett, Consulting Engineer and Head of the Department of Engineering and Science Management at the University of Alaska, Fairbanks, Alaska. The work was performed under Purchase Order No. DACA89-75-0538, Estimating Heating Requirements for Buildings Under Construction in Cold Regions--An Interactive Computer Approach.

The support and encouragement of Francis H. Sayles and William Quinn of USA CRREL are gratefully acknowledged. Peter Woodring of the University of Alaska's Computer Center and Donald Kuhlmann of Honeywell Information Systems assisted greatly in the final stages of computer program development, and their help is especially appreciated. The author also thanks those many Alaskan contractors whose willingness to respond to the contractor survey made that portion of the project successful. Special thanks are also due Ms. Martha C. Sales, who typed the final manuscript of this report.

The contents of this report are not to be used for advertising, publication, or promotional purposes.

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INTRODUCTION

The advantages of continuing construction operations throughout the winter period are many. The owner can obtain use of his completed project sooner. The contractor can enjoy smaller overhead costs, reduced fluctuation in level of personnel and more efficient managerial responsibilities. In addition, some operations, such as transport of equipment over frozen tundra, cannot be carried out except under wintertime conditions, and others, such as carpentry and finishing work, may be more efficient when done in heated enclosures rather than in "exposed" areas in warmer weather. The trend toward more wintertime construction work will no doubt continue, as the pace of development of Alaska and other northern areas quickens.

The purposes of the study reported in this paper were twofold-- 1) To document the temperatures and other conditions that cause shutdown of winter construction operations and 2) To develop and validate a computer program to assist contractors in estimating heat loss from buildings under construction and the costs of temporary enclosures and heating for such buildings.

To fulfill the first purpose stated above, two approaches are described. The first was a review of the literature of construction to find descriptions of projects that have been carried out in cold weather. Over fifty porjects are described for which extreme temperature information is given. The lowest reported temperature was -70°F, on a bridge construction project. The other approach was to conduct a survey of Alaskan contractors to find their "cutoff temperatures" for various

types of construction work and to document other factors that are important in deciding whether to suspend operations in winter. This report summarizes replies to the survey and concludes that many contractors are willing to work at extremely low temperatures, if sufficient economic reward is present.

After a description of "batch" and "interactive" computer programming, the report describes the heat loss and cost estimating computer program in detail. It then presents the complete output from a computer processing session for a sample building project. Next, it reports on an effort to validate the program by comparing actual heat losses for the University of Alaska's Laboratory Building Addition project, constructed in 1973-74, with those estimated for that project by the program. Following this comparison, it is concluded that the program does a relatively good job of estimating heat losses and that it can be of assistance to the construction estimator.

RESEARCH ON "CUTOFF TEMPERATURES"

The cold-weather conditions which may make it difficult or impossible to conduct construction operations are many. Certainly one of the most important of these factors is low temperature. In order to document those temperatures at which various types of construction activities can and cannot be carried out, two different efforts were made. First, the literature of construction was searched for reports of projects conducted under wintertime conditions; several of these reports containing data on temperatures occurring during the construction process have been summarized and are included in this report. Second, a questionnaire survey was made of Alaskan contractors to determine what temperatures would result in shutdown of various types of construction activities. Summaries of these responses are reported. The following section deals with the literature search, and the summary of the contractor survey is given next.

Literature Search

Nearly one hundred articles on cold-weather construction projects were researched for information on temperatures occurring during the progress of construction. Of these, fifty-six sources gave temperature data on a total of fifty-nine projects. Table I summarizes information for these fifty-nine projects in chronological order beginning with the 1924-25 winter, and a list of the referenced projects is given as Exhibit A, entitled "Reference List--Lowest Wintertime Temperatures for Selected Construction Projects."

TABLE I. Lowest Wintertime Temperatures for Selected Projects, as Reported in the Literature

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference*
St. Louis, Missouri	1924-25 winter	4 story garage & 4 story market building	concrete placement	0°F	Concrete entered forms at 70° F due to heating. During setup and curing concrete protected with tarpauling and heated with salamanders. Outside temperatures generally +10 to +20° F.	48
Madison, Wisconsin	1927-28 winter	hotel	concrete placement	-30°F	Canvas enclosure heated with salamanders. Temperatures ranged from "a little above freezing" to -30 F.	49
Vermont	1928-29 winter	several bridges	concrete deck placement	-20°F	Protected with tarpaulins between bridge floor and ice in river, plus hay and paper on top of slab. After removal of curing heat, strength increased despite temperatures as low as -26° F.	44
Lower Fox River, Wisc.	1932-33, 1933-34 winter	river lock	concrete placement	0°F	Cutoff temperature determined by "discomfiture to the workmen".	50

*References are in Exhibit A. Reference List--Lowest Wintertime Temperatures for Selected Construction Projects.

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
					Sand and gravel piles covered with tarpaulins and heated with steam pipes.	
Indianapolis Indiana	Dec., 1933	resurfacing street; paving new highway	concrete pavement placement	+17°F	Protected with burlap and straw. High early strength cement.	47
Southwestern Ohio	Dec., 1933	highway construction	grading; concrete pavement placement	-7°F (concreting)	After final grading, subgrade protected from freezing with burlap and straw. New slab also protected with burlap and straw.	7
Wyoming	1935-36 winter	earth dam	spillway concreting	-32°F	Protected under "old canvas and tentage" with lumber frame. Heat supplied to water and aggregate and under housing by steam coils and wood-burning stoves. Average temperature during concreting = 0°F to +10°F.	20
Toronto, Canada	1936	industrial plant	concrete placement	+15°F	Enclosure of framing and canvas. Roof raised as work moved upward. Steam heaters inside. Inside temperature = 60 - 70°F. Aggregate heated to 50°F, water to 80°F. Delivered in mixer trucks from 1/2 mile away.	52

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Nazareth, Penn.	1936	cement plant	concreting of arch roof	+10°F	Lowest temperature in enclosure = 36°F.	21
Kennebec River, ME	1937-38 winter	dam	concrete placement	-20°F	Form area enclosed. Batch plant enclosed and heated. Concrete delivered through exposed uninsulated pipe 280 ft. long. At -12°F concrete temperature dropped 6°F.	12
Northern NYS	1940-41 winter	large army camp	frame barracks; utilities	-34°F	Heavy snow. 8000 men at peak. Rush schedule. Frozen ground removed after erection of building shells; replaced with unfrozen material prior to placing floor concrete.	36
B.C., Yukon, Alaska	1942	highway	clearing, rough grading, bridges	-40°F	1600 miles, Dawson Creek, B.C. to Fairbanks, Ak, plus short sections to Carcross, Y.T., and Slana, Ak.	32
Excursion Inlet, Ak.	1942-43	barge terminal	piling, docks, buildings, power houses, bridges, riprap	-12°F	2800 men on project; 1 million C.Y. of Riprap; 50 million Bd-Ft of lumber, 20,000 piles.	16

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Fairbanks, Alaska	1943	military buildings	excavating, clearing, blasting, steam thawing, painting	-50°F	Painting inside enclosures; some drilling and blasting of permafrost.	17
Sault Ste. Marie, Mich.	1944-45 winter	lock approach canal	concrete wall construction	-24°F	Total snowfall - 90". Enclosure of insulation board on tubular steel scaffolding, placed around complete wall 878' long, 39' high.	54
Saco River, Biddeford, Maine	1947-48 winter	power dam	concrete placement	-20°F	"Snow and howling winds."	46
Sault Ste. Marie, Mich.	1947-48 winter	repair of canal lock wall	guniting	-23°F	Old wall heated prior to guniting. Enclosure of tubular steel scaffolding and canvas.	55
Minneapolis/ St. Paul Minnesota	1950-51 winter	house building	block masonry	-28°F	Inside "tents"; interior temperature = 65°F.	5
			block masonry, house framing	-10°F	No enclosure; used warm mortar and dry blocks. No wind.	5
Ontonagon, Michigan	1952-53 winter	130 houses	excavation, concreting, carpentry, masonry, plumbing	-30 to -40°F	Average snow = 3 feet. Much work inside "shelters."	22

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Fairbanks, Alaska	1952-53 winter	Air Force base building	permafrost thawing; floor slab const.	"far below 0"	Used circus tent for protection. Temperature in tent = 45°F.	2
Nechako, B.C.	1952	earth dam	placement of clay core	0°F	2% calcium chloride mixed with clay at 0°F; 1% at +10°F.	56
Anchorage, Alaska	1953-54 winter	hospital	concrete placement	-2°F	"Big top" canvas tent for protection, plus portable heaters.	18
Kansas	1953-54 winter	dam	mass concreting	sub-zero	1" thick fiberglass insulation for protection.	25
Wyoming	1954-55 winter	highway	rock excavation	-40°F	Light to moderately heavy snow. Jackhammers kept operable by placing liquid gas in air lines.	53
Yanktown, S. Dakota	1954-55 winter	dam construction	mass concreting	-32°F	Enclosure = 1.9 million cubic feet. Withstood 55 mph wind. 4 locomotive type boilers for heat.	51
North Slope, Ak.	1955 April	base camp construction	tractor trains carrying bldgs. & supplies	+20°F	30 mph wind. Route was 600 miles from Barter Island to 7 DEW Line sites.	11

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Kotzebue, Alaska	Oct.-Dec. 1955	piling placement for building project	drilling in permafrost; placing piling	sub-zero	858 24 inch holes, avg. depth 20 feet.	13
Bethel, Alaska	1955-56 winter	drilling holes for piling	drilling	-30°F	Auger drill used continuously to avoid freezing; 915 18 inch holes, 32 1/2 ft. deep.	42
Ft. Pierre, S. Dakota	1955-56 winter	bridge construction	concrete deck paving	-10°F	-20°F during curing. Heated enclosure over deck; insulation under slab form.	13
St. Lawrence River, Canada & U.S.	1955-56 winter	seaway	steam cleaning rock, placing concrete; excavating & hauling	-5°F (ave. weekly)	Weekly average temperature was below freezing for 3 1/2 months. Concrete placed under tarpaulins or paperboard. Other work outside.	43
St. Lawrence River, Canada	1956-57 winter	power dam on seaway project	concrete placement	-40°F	American contractors shut down for winter. Canadian contractors worked to -40°F.	19
LaTuque, Quebec	1956-57 winter	power dam	concrete placement	-45°F	Heated surfaces to 40 to 50°F; heated sand, coarse aggregate, and water; tarp-covered wood frame enclosures; steam-fed unit heaters.	10

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Oshkosh, Wisconsin	1956-57 winter	building	foundation concreting	+5°F	Used insulated forms of balsam wood insulation and plywood panels.	23
Illinois	1957-58 winter	bridge construction	pier & deck concreting	0°F	Polyethylene film used over sides during pier construction. Large canvas tent placed over top to protect deck work.	3,9
Buffalo, New York	1957-58 winter	Thruway retaining walls	concrete placement	zero range	Balsam wool insulation placed between forms and walers.	24
Huntsville, Ontario	1957-58 winter	bridge	pier construction	-30°F	Pipes under water surface kept river from freezing by bubbling, allowing floating barges to move.	1
Chicago, Illinois	1958	bridge	bituminous concrete paving	near zero	Hot mix transported in insulated trucks with tarpaulin covers. Surface rolled and left exposed.	30
Bratsk, S. Central Siberia	late 1950's	hydroelectric project	concrete placement	-50°F	---	26, 40

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Niagara Falls, N.Y.	Jan. 1960	power project	concrete placement	26°F (monthly mean)	90,000 CY placed in January. "Winterized" forms for concrete conduits.	41
Montreal, Canada	1960-61 winter	600,000 SF office building	welding concrete wk.	near 0 +10°F	Joints heated with propane torches. Used insulating blankets during curing but no additional enclosures or heating.	35
Rockford, Illinois	1961-62 winter	prestressed concrete water storage reservoir	concrete placement	+11°F	Concrete heated to 70°F.	39
Revere, Mass.	1962-63 winter	department store	fill placement	0°F	---	56
LaPlume, Penn.	1962-63 winter	3 dormitories	various, incl. concrete work	-15°F	Enclosures--walls: scaffolding towers & polyethylene sheeting; roof: trusses and tarpaulins. No lost time during winter.	33
Barrow, Alaska	1963-64 winter	water supply dam	placing ice core, installing oil drum "riprap"	-30°F	---	4

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Baie Comeau, Quebec	1963-64 winter	dam construction	concrete placement	-25°F	Before winter, every other monolith completed. During winter, remaining monoliths placed, under wood-framed plastic and canvas enclosures.	27
Regina, Saskatchewan	1964-65 winter	campus buildings	concrete placement	-15°F	Most above-ground concrete was placed at average winter temperatures of -5°F, using enclosures.	15
Forty Mile River, Y.T.	1965-66 winter	bridge	coffercams, excavation, tremie concrete, piers, steel, deck	-70°F	34 days in which temperature did not rise above -60°F. Cofferdam driven through ice.	14
Fairbanks, Alaska	1966 Nov.	department store	concrete batching & placing	-55°F	---	29
Ithaca, New York	1969-70 winter	dormitories	concreting, masonry	-18°F	Temporary "roof" raised as construction proceeded. Adjustable exterior enclosure for masonry wall construction.	38

Location	Date	Project Description	Activities	Lowest Temp.	Other Data	Reference
Bethlehem, Pennsylvania	1969-70 winter	bridge	deck concreting	below zero	Inflated plastic dome for protection.	31
Labrador, Canada	late 1960's & early 1970's	hydroelectric project	transmission towers, above & below ground buildings	-55°F	---	8
South Dakota	1970-71 winter	operation & maint. shop building	Concrete placement for foundation & walls.	-30°F	38 days with temperatures below 0°F. Work performed under shelters of wood, polyethylene and tarpaulins.	28
Ontario, Canada	various	power dams	concrete placement	-30°F	Short aggregate conveyors operate to -30°F, if pulleys are protected. Concrete hauled in open trucks if temperature is not "well below zero" and haul is not greater than one mile.	34
Michigan	various	highway construction	compaction of cohesive & granular fill	+20°F	Material placed unfrozen; froze after compaction.	56
Soviet Union	various	silo construction	concreting	-29°F	Sliding formwork and infared radiation.	6
West Germany	various	building construction		+23°F	Open sites, with no protection.	45

EXHIBIT A. Reference List--Lowest Wintertime Temperature for Selected Construction Projects

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Referring to Table I, one notes that the coldest temperature reported for a building construction project was -55°F. Also, dam construction at a hydroelectric project was carried out at temperatures as low as -50°F, while, at another similar project, transmission lines and buildings were installed during -55°F temperatures. Canal lock construction has continued in temperatures down to -24°F, and operations on a barge terminal project withstood -12°F weather. Temperatures as low as -40°F were recorded during two highway construction projects. Furthermore, auger drilling for piling has been carried out at -30°F. The coldest temperature found during the literature search was -70°F, on a bridge construction project on the Forty Mile River, Yukon Territory. Some tremie concrete for this bridge was placed during -60°F temperatures, but most other pours took place at relatively mild temperatures of -40°F to -45°F. On this project, which was built during the winter of 1965-66, there were 34 days on which the temperature did not rise above -60°F.

Contractor Survey

To ascertain "cutoff" temperatures for various activities below which work is suspended, a survey was taken of contractors doing business in Alaska. Questionnaires were mailed on March 8, 1975, and the last response was received on April 7, 1975. A copy of the questionnaire is included as Exhibit B. The response percentage was 40%, as indicated in Table II. A listing of those companies responding to the survey is attached, as Exhibit C.

Table III summarizes responses to the principal question asked by the survey, "What is the lowest temperature at which the following

F. LAWRENCE BENNETT, P.E.
CONSULTING ENGINEER
P. O. BOX 80548
COLLEGE, ALASKA 99701

March 8, 1975

Gentlemen:

The U.S. Army Cold Regions Research and Engineering Laboratory has engaged me to conduct a modest survey of Alaskan construction contractors. The purpose of the survey is to determine temperature ranges in which various types of construction activities can be performed. Your assistance by completing as much of the following brief questionnaire as possible would be greatly appreciated:

1. What is the lowest temperature at which the following types of activities can be performed?

Machine excavation _____
Hand excavation _____
Earth moving & grading _____
Paving _____
Concrete formwork, resteel, placement, etc. _____
Concrete placement & finishing _____
Steel erection _____
Block and stone masonry _____
Roofing _____
Finish carpentry _____
Painting _____
Electrical installation _____
Piping & mechanical system installation _____
Pipe welding _____
Erection of pre-built components, such as precast concrete panels, prebuilt metal buildings, etc. _____
Layout, surveying, etc. _____
Loading, unloading _____
Other _____________ _____
_____________ _____

2. For those activities for which you have indicated "cut-off" temperatures, what determines that temperature (effect on people, effect on machinery, soil conditions, etc.)?

____

____

____

3. Admittedly, the designation of temperature as the only determinant of activity shutdown is too simple an approach. What other factors besides temperature are important in a decision to suspend work in the winter?

____

____

____

4. Other comments? ____

____

____

Thank you for your help. A stamped, self-addressed envelop is enclosed for your reply.

Sincerely yours,

F. Lawrence Bennett

F. Lawrence Bennett, P.E.

TABLE II. Questionnaire Survey Response

Total sent	87	
Returned undeliverable	3	
	84	100%
Replies received	34	40.5%

EXHIBIT C. Companies Responding to Survey Questionnaire

A & A Roofing Company, Inc.
P. O. Box 314
Fairbanks, Alaska 99701

Acme Electric Co. Inc.
P. O. Box 532
Fairbanks, Alaska 99701

Alaska Pacific Ventures
4624 Seward Highway
Anchorage, Alaska 99501
Mr. James Wong

Alyeska Electrical & Engineering
P. O. Box 4-FF
Anchorage, Alaska 99509

Arctic Constructors
4600 Dale Road
Fairbanks, Alaska
Mr. Eugene Kulawik

Arctic General, Inc.
Box 80122
College, Alaska
Mr. Richard D. Karr

Aurora Plumbing and Heating
3027 E. Tudor Road
Anchorage, Alaska 99501

Baugh Construction Co.
922 Poplar Place South
Seattle, Washington 98144
Mr. L. M. Baugh

B-E-C-K Constructors
Taku Apartments
4001 Seward Highway
Anchorage, Alaska 99503
Mr. W. D. Parker

Chandler Plumbing & Heating
129 Minnie Street
Fairbanks, Alaska 99701

Earthmovers of Fairbanks
925 Aurora Drive
Fairbanks, Alaska 99701
Mr. Fred Walters

Electrical Contractors of Alaska Inc.
1705 Ship Avenue
Anchorage, Alaska 99501

W. R. Grasle Company
P. O. Box 1187
Fairbanks, Alaska 99701

Green Associated J.V.
Pouch 85
Fairbanks, Alaska 99707

Interior Masonry
Box 2311
Fairbanks, Alaska 99701

Johnson Plumbing & Heating, Inc.
P. O. Box 8-9034
Anchorage, Alaska 99508

Locher Company
Drawer 4-JJ
Anchorage, Alaska 99509
Mr. Herbert J. Frensley

Lundgren's Pacific Construction Co.
P. O. Box 2752
Fairbanks, Alaska 99701
Mr. D. J. Martsolf

Manson-Osberg Co.
1132 North 128th Street
Seattle, Washington 98133
Mr. Clyde Hovik

Michael Baker Jr, Inc.
P. O. Box 3109
Fairbanks, Alaska 99701
Mr. William B. McMullen

Michael Baker Jr, Inc.
Fort Wainwright, Alaska
Mr. Cecil Palmer

Modern Construction, Inc.
P. O. Box 965
Fairbanks, Alaska 99701
Mr. Ross Adkins

Office of Planning & Construction
University of Alaska
Providence Avenue
Anchorage, Alaska 99501

Peter Kiewit Sons' Co.
Box 848
Fairbanks, Alaska 99707
Mr. S. C. Stephens

Regan Steel & Supply, Inc.
P. O. Box 1176
Fairbanks, Alaska 99701

Sandland Construction Co. Inc.
3800 Arctic Blvd.
P. O. Box 4-193
Anchorage, Alaska 99509
Mr. Henry Sandland

Sandstrom Inc.
P. O. Box 1993
Fairbanks, Alaska 99701

Sta-Con, Inc.
3177 19th Street
Fairbanks, Alaska 99701
Mr. Robert S. Morton

Sunrise Electric Inc.
3707 Arctic Blvd.
Anchorage, Alaska 99501

Swalling Construction Co. Inc.
Box 1039
Anchorage, Alaska 99510
Mr. A. C. Swalling

Western & Associates, Inc.
1642 Dowling Road
Anchorage, Alaska 99502

Wick Construction Co.
720 North 35th Street
Seattle, Washington 98103
Mr. Andrew P. Wick

Woodruff Construction Co. Inc.
P. O. Box 4-2-7-
Anchorage, Alaska 99509

Yutan Construction Company
P. O. Box 1775
Fairbanks, Alaska 99707
Mr. James A. Carroll

TABLE III. Summary of Responses to the Question, "What is the lowest temperature at which the following types of activities can be performed?"

Activity	Absolute Low, °F				Lowest for Efficient Operation or Within Enclosure, °F			
	Responses	Range Lo	Range Hi	Average	Responses	Range Lo	Range Hi	Average
Machine Excavation	15	-70°	-20°	-37°	10	-30°	+32°	- 1°
Hand Excavation	11	-70°	+32°	-22°	12	-30°	+33°	+18°
Earth Moving & Grading	11	-45°	-20°	-35°	9	-20°	+32°	+13°
Paving	14	+15°	+45°	+32°	4	+25°	+60°	+41°
Concrete Formwork	11	-50°	-10°	-25°	7	-10°	+33°	+10°
Concrete Placement	6	-50°	-25°	-31°	12	+20°	+40°	+32°
Steel Erection	10	-50°	-20°	-32°	8	-30°	+30°	- 1°
Block & Stone Masonry	5	-50°	0°	-25°	12	0°	+40°	+31°
Roofing	7	-30°	+15°	-13°	8	0°	+60°	+24°
Finish Carpentry	5	-50°	-10°	-27°	9	+15°	+50°	+36°
Painting	7	-50°	+40°	+13°	10	+32°	+60°	+42°
Electrical	14	-70°	-10°	-31°	7	+20°	+40°	+28°

Activity	Absolute Low, °F				Lowest for Efficient Operation or Within Enclosure, °F			
	Responses	Range Lo	Range Hi	Average	Responses	Range Lo	Range Hi	Average
Piping & Mechanical	10	-50°	-10°	-27°	5	+20°	+40°	+29°
Pipe Welding	9	-50°	0°	-21°	3	-30°	+33°	+ 8°
Pre-Built Components	13	-50°	-10°	-28°	6	-30°	+33°	+ 9°
Layout & Surveying	17	-50°	0°	-33°	4	-30°	+20°	+ 2°
Loading & Unloading	14	-60°	-10°	-39°	4	-35°	+20°	- 1°
Subsurface Exploration	1	-	-	-40°	-	-	-	-

activities can be performed?" It is noted that responses to that question fell into two categories. Some respondents gave the absolute lowest temperature, while others gave the lowest temperature that would allow efficient operation or the lowest temperature that would be permitted inside an enclosure where the work was being performed. For example, the average response for the question related to machine excavation was -37°F as the absolute low; those who reported on the lowest temperature for "efficient" machine excavation gave an average answer of -1°F. Another example is the question on concrete placement. Here, the "absolute low" answer averages -31°F; in this case the respondent is suggesting that the outside temperature can be this low, provided proper enclosures and heating are provided. The average response for the case of concrete placement inside enclosures suggests that the lowest permissible inside temperature is +32°F.

Table III reveals widely differing responses to the question of cutoff temperatures for each of the various categories, as would be expected from so diverse a group as Alaskan contractors. Note, for example, that one contractor believes that layout and surveying work can be done at temperatures as low as -50°F, while another feels that the absolute lowest possible temperature for this sort of activity is 0°F. The average of the responses in each category are probably as expected, ranging from +32°F for paving to -39°F for loading and unloading (neglecting the one -40°F entry for subsurface exploration) in the "absolute low" classification. In the "lowest for efficient operation or within enclosure" column, the average ranges from +42°F for painting to -1°F for machine excavation, steel erection and loading and unloading.

As indicated by the questionnaire form in Exhibit B, respondents were also asked to indicate what factors determined the cutoff temperatures they had given and what other factors, besides temperature, were important in deciding whether to shut down their operations. Also, an opportunity for other comments was provided.

Appendix I contains unedited and unsummarized responses to these three questions. From these listings, it can be seen that the effect on people is one of the primary reasons that cold temperatures cause winter shutdowns. Also, equipment is adversely affected by such problems as hydraulic system and metal failure. Further, low temperatures affect such materials as electrical cable (insulation cracking) and soil (freezing). While such answers may seem "obvious," the writer believes that it is important to document these opinions from the contractors themselves.

In answer to the question, "What other factors besides temperature are important in a decision to suspend work in the winter?", the respondents listed such factors as wind, snow, lack of daylight, soil moisture, and icing conditions. In addition to these "physical," or "environmental," factors, they also cited cost of transportation, type of work, size of job, availability of personnel, effect on other phases of the project, union attitude and quality control as considerations that might keep one job operating and shut another down, even under similar temperature conditions. Money was the important "other factor" in several responses. One contractor said, "... in other words economics. There is no temperature cutoff unless coupled with costs. It just costs more money at lower temperatures. The impossible just costs more."

The "other comments" question resulted in several interesting ideas. One suggested that work on the Trans-Alaska Pipeline had brought about approaches to cold weather construction that were considered impossible ten years ago. Another made a suggestion that seems especially important in interpreting the numbers and comments included in this section; he said, "Every situation is different--as reflected by unit bid price variation, area work load, etc. No hard and fast rules have been revealed to me, ever!"

"HEATCOST"--A PROGRAM FOR ESTIMATING THE COST OF TEMPORARY HEATING AND ENCLOSURES DURING CONSTRUCTION

General Description

The major effort undertaken in this project has been to develop a computer program that the construction estimator can use to estimate the costs of temporary heating and enclosures for buildings under construction in cold regions. Desirable characteristics of such a program should include ease of use, ability to consider all relevant variables, accuracy in predicting actual heat loss and costs, and compatability with other computer systems. It is believed that these goals have been achieved with the present project. The work accomplished included the design and coding of the program in FORTRAN; the debugging of the program, first on the IBM 360/40 computer at the University of Alaska's Fairbanks campus and later on the Honeywell 6040 Computer at Honeywell's Portland, Oregon, Data Center, using data from a hypothetical sample project; and the validation of the program using data from the construction of the Laboratory Building Addition project at the University of Alaska.

The program operates in a timesharing mode, allowing input data to be entered by means of a remote keyboard terminal. The program "prompts" the user by printing commands indicating what data are required, and in what order, at various locations throughout the program. The version of FORTRAN used makes the program fully compatible with any Honeywell computer in the 600, 6000 or 66/00 series, plus computing equipment produced by Control Data Corporation and Digital Equipment Corporation. In particular it should operate "as is," with no

changes, on the Honeywell time-sharing computer system at Dartmouth College. With minor modifications, the program will operate on other computer machinery.

In preparing to enter data for the program, the user segments the building's various structural elements into walls, roof and floor. For each wall, he must prepare information on various types of windows and doors (up to three types of each are permitted for each wall), including number, dimensions, U factor, crack infiltration factor, solar radiation transmission ratio and labor and material costs. For the roof, dimensions and U factor must be supplied. If the roof has enclosed openings, data similar to that given for windows and doors must be developed. A U factor must also be determined for the floor. The unit cost of heating and the monthly cost of maintaining enclosures (as a percentage of the enclosures installation cost) must be estimated. Finally, for each month during which the structure will be enclosed and heated while under construction, the average inside and outside air temperatures, the average soil temperature, and heating effects due to solar radiation must be developed for input to the program.

With the program stored at the central computer facility, the analyst first connects the remote keyboard terminal to the central processor and communicates with the central facility, through the keyboard, using a few commands to make the program available. Then, he follows instructions printed by the program on the keyboard, to place data into the computer. All data for one wall, including that for its windows and doors, if any, are given together, followed by data for the next wall. When all wall data have been supplied, roof and roof enclosure data are requested. Then, information on the floor is

given. Heating system and maintenance cost data are given next, followed by the data for each month, as described above. After data for a month are typed in, the program prints estimates of the heat loss and the costs of heating and enclosure maintenance for that month. After the last month, a grand summary of heat losses and costs is printed.

Since the estimator may desire to analyze the effect on costs of alternate enclosures methods, the program is written so that, after the grand summary is printed, revised data may be entered. These revisions are typed in, and the revised heat losses and costs are typed out by the program. This process may continue for as many alternatives as desired.

The following section gives some general information on the concepts of timesharing, or interactive, computer systems. Following that section the program is described in detail, typewriter output from a sample timesharing session is discussed and the results of the validation effort are presented.

Batch vs. Interactive Computing

Today, the usual method of operating a computer system is through a technique known as "batch processing." Typically, under such a system, the computer operations staff assembles a stack of several computer program decks into a single "batch." These programs are then read into the computer one at a time, each is executed, and the output is produced. The user prepares his input on cards, has these data read and processed, and then examines the resulting output. If changes are desired, he then revises the input, and the process is repeated. Modifications of the above operating procedure have allowed increased

efficiencies in batch processing, such as a system that allows reading, computing and printing to be done simultaneously. For example, while the fifth job in the stack is being read, the computer might be performing calculations on job four and printing results from job three.

For large computer jobs with many time-consuming calculations, batch processing is likely to be the most efficient of available techniques, because it is necessary to dedicate the entire processing unit to one program for relatively long periods. However, under some conditions it may be desirable to use a different approach, that of interactive "time-sharing."

Massey (7)* has written, "The goal of time-sharing is to provide a number of people working independently with direct on-line access to the full power of the computer." With such a system, the user supplies data from a remote terminal, the data are processed at a centrally-located computer, and the results are returned to the terminal. Thus, the user "shares time" with other users, using the central processing unit in short spurts when needed.

A significant feature of time-sharing systems is the lack of a need for a complete card file of input data. The input is entered, one piece of data at a time, through the remote terminal, which consists of a keyboard similar to that on a typewriter. Also, rather than waiting for the computer operations personnel to obtain the printed output from each processing run, the user has results available at the terminal almost immediately. Thus, he can revise some data and continue the analysis, without having to "get in line" with another complete pro-

---

*Numbers in parentheses refer to entries in Exhibit D. Reference List--HEATCOST Computer Program.

EXHIBIT D. Reference List--HEATCOST Computer Program

1. Bennett, F. Lawrence. Temporary Enclosures and Heating During Construction--A Case Study of The Laboratory Building Addition, University of Alaska, Special Report No. , U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1974.

2. Design Heat Transmission Coefficients, Canadian National Research Council, Division of Building Research, Technical Paper No. 168, Ottawa, June 1965.

3. Down, P. G. Heating and Cooling Load Calculations, Oxford: Pergamon Press, 1969.

4. "Insulation of the Home." Better Building Bulletin No. 2, Canadian National Research Council, Division of Building Research, 1956.

5. Jennings, Burgess H. Heating and Air Conditioning, Scranton, International Textbook Company, 1956.

6. Mirth, Richard A. "The Sun Can Heat Our Homes--Even in the North," The Northern Engineer, Vol. 6, No. 3, Fall 1974, pp. 3-10.

7. Massey, L. Daniel. Computer Basics for Management, Braintree, Massachusetts: D. H. Mark Publishing Company, 1968.

8. Saczalski, Kenneth J. "Low Cost Graphics and Alphanumeric Terminals." Modern Computer Technology and You. ASCE National Structural Engineering Convention Preprint 2501, April 14-18, 1975.

9. Seeley, Samuel, Norman H. Tarnoff, and David Holstein. Digital Computers in Engineering. New York: Holt, Rinehart and Winston, Inc., 1970, pg. 53.

cessing run, as would be the case under batch processing.

Four words sometimes used interchangeably for the technique being described actually designate various characteristics of the total approach. The word "time-sharing" has already been discussed as indicating that the user shares processor time with other users. The term "remote computing" suggests that terminals remote from the computer center are used to transmit and receive information. Important to this concept is the idea that the user need not invest in a complete computer facility; he needs a terminal, and he must also, of course, share in the cost of the central processing unit.

Remote terminals of many types, both portable and non-portable, are available. One of the earliest was the familiar Teletype unit. The terminal used to process data for the program described in the following section is shown in Figures 1 and 2. A recent paper (8) lists fifty-eight different remote terminal models currently available, of which twenty-five are portable. Twenty-eight manufacturers are represented in the list. Rental rates range from $40 to $200 per month for portable terminals and $40 to $250 per month for non-portable units, depending on the features included.

Data are normally transmitted over voice-grade telephone lines. To convert digitized data at the terminal to and from audio frequency signals for transmitting over telephone lines, a "modem," standing for "modulate and demodulate," is used. The author can testify that, despite a communications system that is sometimes considered less than ideal, transmission of data between Fairbanks, Alaska and Portland, Oregon, worked remarkably well during the process of developing and validating the program described below!

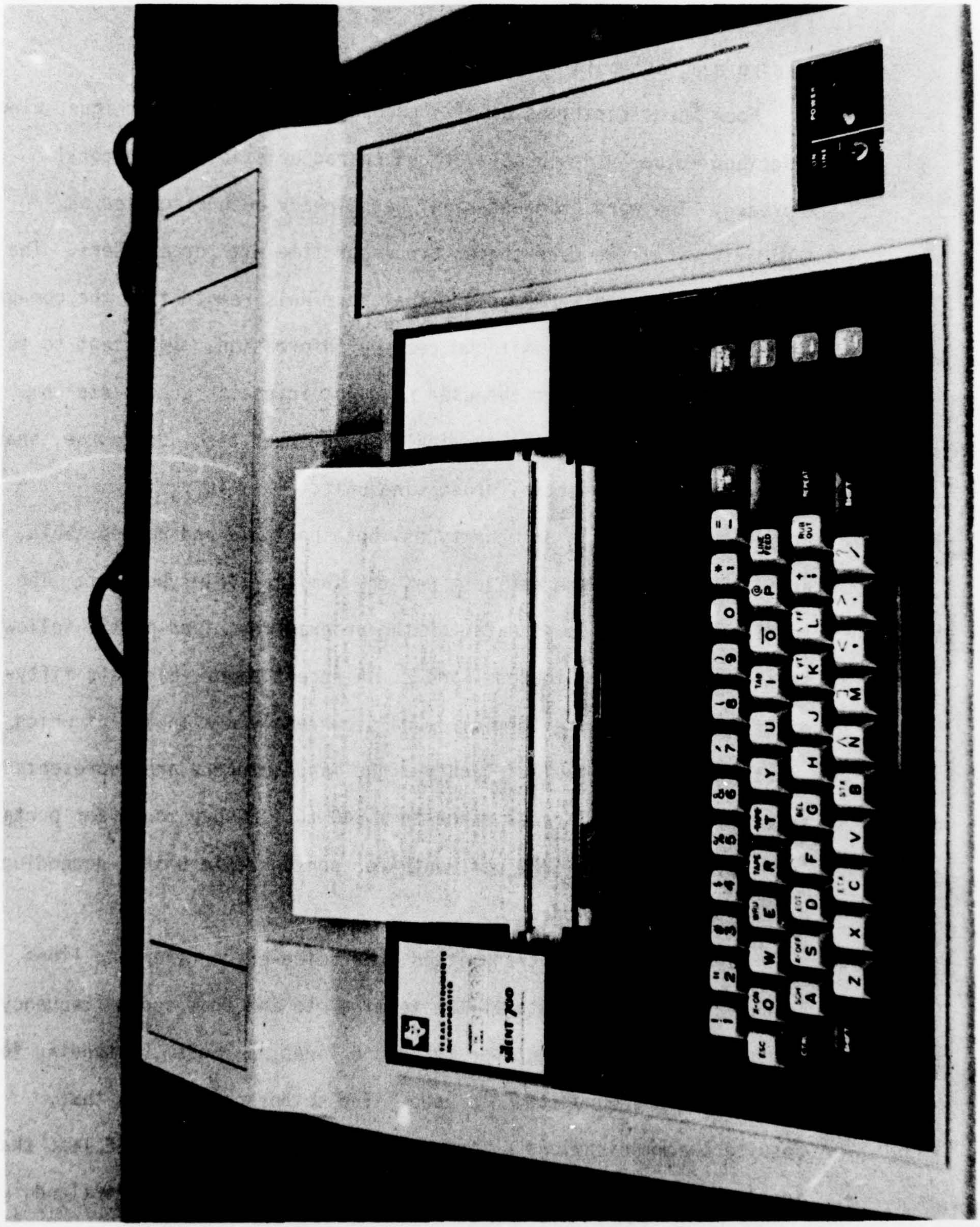

Figure 1. Texas Instruments "Silent 700" Terminal, Showing Output from HEATCOST Program

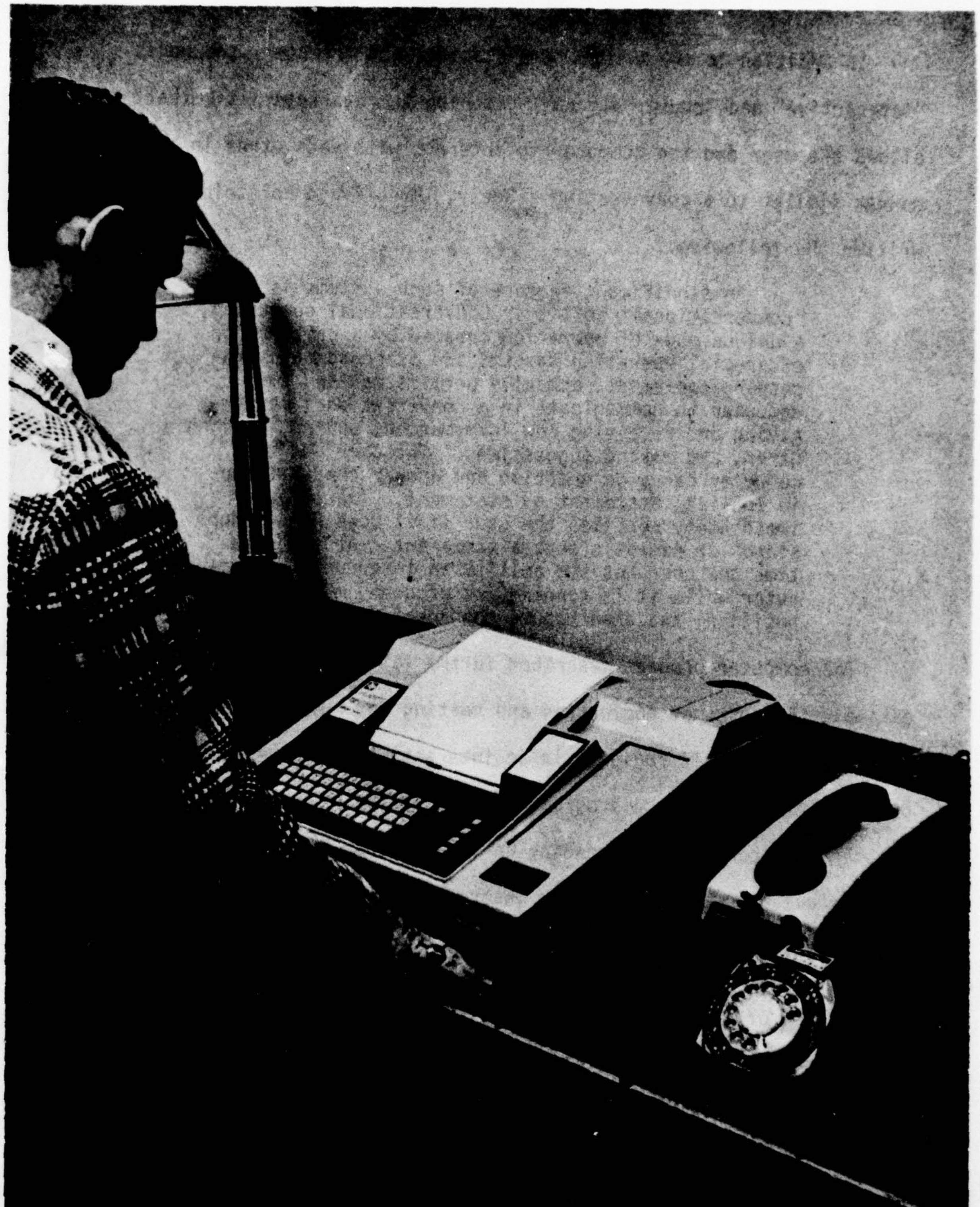

Figure 2. Texas Instruments "Silent 700" Terminal in Use, Showing Telephone and Modem Connection

In addition to the terms "time-sharing" and "remote", the words "interactive" and "conversational" describe the characteristic that allows the user and the computer to interact with each other in a manner similar to a conversation. Seely, Tarnoff and Holstein (9) have written the following:

> "A significant feature of such systems is their 'conversational' ability. Conversational computing, a unique mode of operation created by a combination of special operating systems and standard data processing equipment, actually permits man and the computer to communicate in a conversational manner--giving and receiving new information, correcting each other, and making suggestions. The user and the computer carry on question and answer conversation in English, statement by statement. The computer immediately notifies the user if it does not 'understand' or cannot accept a statement. At the same time the user has the ability to interrupt the computer while it is running its program, modify his position, and then resume the job."

The computer program described in the following sections, used to estimate the costs of enclosures and heating for buildings under construction in cold regions, is an interactive, or conversational, program. Throughout the program, it prompts the user with certain questions or commands. Depending on the response, the program asks further questions, gives further instructions, performs certain calculations or terminates.

Description of Program Procedure

This section describes the various steps through which the HEATCOST computer program progresses in developing estimates of heat loss and heating and enclosures costs for a building project. The next section contains both a listing of the entire keyboard output for a typical timesharing session, as well as an explanation of various parts

of the input and output.

Reference should be made to Appendix II, which contains a listing of all statements in the FORTRAN program. Included in the program, as comments, are definitions of each variable used in the program, plus several statements explaining the steps which the program follows.

The interactive feature of the program allows the user to input changes to initial data after those data have been processed, using the keyboard, in order to analyze the effects of various enclosure alternatives on estimated heat loss and total cost. The first part of the discussion which follows describes the operation of the program during the stage when initial data are being read and processed; later, a description of the data revision process is given.

After printing the program description, "HEATCOST--A PROGRAM FOR ESTIMATING THE COST OF TEMPORARY HEATING AND ENCLOSURES DURING CONSTRUCTION," the program asks that a project identification, containing up to 60 characters, be typed. After this information is typed on the keyboard, the program then repeats the identification that was typed. Quantitative data input follows, with information first for each wall, then for the roof, then for the floor, then heating method and cost, together with average expected inside temperature and monthly maintenance cost, and finally data for each month during which the heating and enclosures methods are expected to be employed.

For each wall, the program asks that the basic wall dimensions be given in feet, followed by the overall U factor (coefficient of heat transmission) for the wall, including any expected average wind effect. Dimensions of the U factor are BTU's per hour per square foot per Fahrenheit degree temperature difference. For each wall, it is also

required that a designator be specified which indicates whether the wall is below or above grade. If above grade, the estimated heat loss will be calculated based upon the temperature difference between the inside air and outside air, whereas if the wall is below grade, the heat loss will be based upon the difference between inside air and soil temperature. Finally, for each wall a "wall orientation designator" will be supplied. This designator will indicate whether the wall is south-facing, east- or west-facing, or north-facing. This last information will be used with solar radiation data to be supplied later for each month.

After the basic data have been supplied for a wall, the program allows data to be input for up to three different types of windows for that wall. Information supplied concerning windows includes the number of the given type of window, its height and width in inches, its U factor (coefficient of heat transmission in BTU's per hour per square foot per Fahrenheit degree temperature difference between inside and outside air), a crack infilration factor which indicates the estimated infiltration of air through the perimeter of the window in cubic feet per hour per foot of perimeter, a solar radiation transmission factor between zero and one, where 0.0 indicates no transmission of radiation and 1.0 indicates complete transmission of solar radiation, and the cost of installing the window per square foot for both labor and material. It is assumed that the windows are covered with temporary enclosures during the cold weather period and that, therefore, the cost of installing these "windows" is part of the temporary enclosures costs. If the windows are a permanent installation, the costs per square foot of labor and materials should be omitted.

After data for up to three window types have been input for the wall, the program asks that similar information be input for up to three door types. These data are to be of the same type and in the same order as those given for windows. After the door data have been input, the program asks whether the wall whose data have been input is the last wall. If this is not the case, the program then asks for data for the next wall, beginning with basic wall data, followed by data for up to three window types and then for up to three door types. This process continues until the question, "IS WALL N THE LAST WALL," is answered with a "YES," at which time the program begins calculating and printing information about each wall.

Wall calculations for each wall include the following:

1. Total area for all windows and for all doors,
2. Total perimeter for all windows and for all doors,
3. Labor and material costs for installation of all window temporary enclosures and all door temporary enclosures,
4. The sum of the products of area times U factor for each window type, and the sum of the products of area times U factor for all door types,
5. The sum of the products of window perimeter times crack infiltration factor times 0.018 for all window types, and the sum of the products of perimeter times crack infiltration factor times 0.018 for all door types (this calculation will be explained in more detail below),
6. The sum of the products of window area times solar radiation transmission factor for all above-grade windows in this wall, and the sum of the products of door area times solar radiation transmission factor for all above-grade doors in this wall.
7. The net area of the wall, and
8. The product of the net wall area times the U factor for this wall.

After completing the above calculations, the program prints gross, window, door, and net wall areas; labor and material costs for doors

and windows; U factor times area products for wall, windows, and doors; crack infiltration product for windows and doors; and solar radiation products for windows and doors. It performs the above input, calculations and printing procedures for each wall, adding to appropriate totals as it proceeds.

After completion of all wall calculations, the program next asks for data on the roof, including length and width in feet and heat transmission factor (U factor). It then asks for data on any temporary enclosures that may be anticipated in the roof structure. These data are identical to those for the window and doors; two different types of roof temporary enclosures may be included, and, for each, the number, length and width in inches, U factor, crack infiltration factor, solar radiation transmission factor, and installation labor and material costs are to be given. If there are permanent penetrations through the roof, such as skylights with permanent glazing already in place, data for these should be included, but, since they are permanent installations, no labor or material costs should be included, as the program is intended to accumulate only those costs associated with temporary enclosures and heating. Roof calculations are similar to those for each wall, including calculations for gross, enclosures and net area; perimeter of enclosures; sum of the products of enclosure U factor times area; sum of the products of crack infiltration factor times perimeter times 0.018; sum of the products of the solar radiation transmission factor times the area for each roof enclosure type; and labor and material costs for any temporary roof enclosures.

Data on the floor are of two types only, using the assumption that the floor area is the same as that of the roof. Data supplied for the floor are the heat transmission factor (U factor), and a designator which indicates whether the U factor is based on soil temperature or on outside air temperature. As noted in (3), coefficients of heat transmission through floors are usually determined experimentally, and it is, therefore, necessary to know whether the factor was based on the difference between inside and outside air temperatures or the difference between inside air and soil temperatures. After reading floor data, the program prints the gross area of the floor and the product of U factor times area for the floor.

Next, the program asks for the description of the heating method and, following that, the cost per thousand BTU's of heating, the average inside temperature (which may be later modified for any particular month), and the monthly cost of maintaining the temporary enclosures, given as a percentage of the total installation cost (which may also be modified for any particular month).

After printing the information on heating method, unit heating cost and inside temperature, the program proceeds to work through each month during which the temporary heating and enclosures system will be in operation. For each month, it asks for the following information: name of the month, number of days in the month, average outside temperature during the month, average soil temperature during the month, average inside temperature (if this temperature is different from that given initially as the "average inside temperature"), maintenance cost percent (if this percent is different from that originally given as that "maintenance cost percent"), and average daily solar radiation, in

BTU's per square foot, for horizontal surfaces, vertical south-facing surfaces and vertical east- or west-facing surfaces.

Solar radiation data will vary with location as well as with time of year and are based on climatic records for the location being studied. Reference (6) gives solar radiation data for several locations in Alaska. Table IV gives the data for Fairbanks from Reference (6).

Heat loss and cost calculations are then performed for the month under study. For those walls above grade, the calculations of heat loss through the wall is as follows:

BTU loss = (Inside temperature - outside air temperature) x (24 hours per day) x (number of days) x (sum of all U factor times wall area products)

For below-grade walls, the calculation is similar, with soil temperature substituted for outside air temperature. For windows and doors, the calculation is similar to that for above-grade walls, except that the sum of the U factor times window areas and door areas, respectively, is used in place of the sum of the U factor times wall areas.

The calculation of crack infiltration losses is based on a method suggested by Jennings (5). The basic heat loss is expressed as

Crack Infiltration Loss (BTU's per hour) = $0.018 \times Q \times \Delta T$,

where Q is the air entering by infiltration, in cubic feet per hour, and ΔT is the difference between the inside and outside air temperatures.

As noted, this calculation results in the heat loss by infiltration in BTU's per hour. Thus, since a total of all crack infiltration factors for each window times their respective perimeters has already

TABLE IV. Average Daily Solar Radiation by Month for Fairbanks, Alaska, BTU/SF (from 6.)

	J	F	M	A	M	J	J	A	S	O	N	D
HORIZ	63	272	806	1390	1820	1955	1755	1242	730	313	118	22
VERT S	718	1452	2095	1721	1310	1112	1052	1192	1380	1190	507	404
VERT E-W	112	342	822	1238	1310	1465	1230	993	715	348	175	49

TABLE V. Monthly Data for Input to Validation Run

		Average Temperatures, °F			Solar Radiation, BTU/SF		
Month	No. of Days	Inside Air	Outside Air	Soil	Horizontal	Verticals	Vertical E or W
End January 1974	6	40	-32	35	12	139	22
February 1974	28	47	-18	35	272	1452	342
March 1974	31	55.5	8	35	806	2095	822
1st Half April 1974	15	49	27	35	695	860	619

been calculated, it is now necessary to multiply this sum by the difference between inside and outside air temperatures, by 24 hours per day and by the number of days in the month. A similar calculation is then made for infiltration through all cracks around doors. The Jennings book (5) contains, on page 152, a table of suggested values of infiltration factors, in cubic feet per hour per foot of crack, for permanent doors and windows.

After the total crack infiltration has been estimated by the method explained above, the result is divided by two, to reflect the assumption that one-half of the air that passes through the cracks will be entering the building, while the other half will be leaving the building. Thus, only one-half of the total air moving through window and door cracks must be heated to the inside air temperature. Roof enclosure cracks are handled in a similar fashion.

The heat gained by solar radiation is calculated by multiplying the solar radiation for the month, in BTUs per square foot, on horizontal, vertical south-facing and vertical east- or west-facing surfaces, by their respective products of area times solar radiation transmission factor for enclosures located on these surfaces.

Following completion of the above calculations, the sum of all BTU losses is calculated for the month, and the solar heat gain is deducted. Then, heating costs and enclosures maintenance costs are found, and all calculated information for the month is printed.

The program then asks whether the month being processed is the last month, and, if the answer is "NO", it asks for data on the following month, after which calculations identical to those described above are performed. When the answer to the question, "IS THIS THE

LAST MONTH" is "YES", the program then calculates and prints grand summaries of heat loss and costs.

After completing the grand summary calculations and printing, the program asks "DO YOU WISH TO REVISE SOME INPUT DATA". If the answer is "NO", the program terminates. If the answer is "YES", the program returns to the beginning and prints the project identification that was input earlier. It then proceeds in the same order as previously, asking whether there are revisions to the various sections of data. If so, the requests for these sections of input are printed, and the analyst would then type in the required data. If no revisions are desired for a certain section, the program branches over the command to read data, assuming that the data previously input will be used for the revised analysis.

If revisions are to be made for the basic wall data for the first wall, this information is then typed in as input. If these revisions are not required, the program then asks whether revisions are required for each of the three types of windows in this wall. In each case, if any element of data for a window is to be changed, then all elements of data for that window type must be re-entered as data. Similarly, any revisions for door data for this wall are input through the key-board. Following input of any revisions for the first wall, the program asks whether this is the last wall, and if so, transfers to reading any revisions for the roof data. If it is not the last wall, then the program requests any revisions for wall two and its associated windows and doors. In a similar fashion the program proceeds until all walls have been revised. Following the input of all revised wall data, the program calculates all wall information, in a fashion identical to

that which it did for the first run of the analysis.

Then it asks whether there are revisions to roof data. If any roof data are to be changed, a message requesting the input of all roof data is then typed, after which the analyst would input the required data. Next, if any revisions to roof enclosure data are required, they will be requested and are typed in. Then, the program performs roof calculations as it did on the initial pass through the program. If revisions to the floor U factor or below grade designator are required, these would be input next, followed by any changes in heating description or costs or the average inside temperature or monthly maintenance cost.

The program then turns to a consideration of each month during which the temporary enclosures and heating will be used. It asks, in turn, whether any month is to have its data revised. If the data for a particular month are to be changed, the program will ask that the month name, number of days, average outside temperature, average soil temperature, average inside temperature (if different from the original input), maintenance cost percent (if different from original input), and three solar radiation values be input. After these data have been typed in, or after a "NO" answer to the question "ARE THERE REVISIONS TO THIS MONTH'S DATA", the program performs heat loss calculations for the month, and prints the results, in a fashion identical to that employed during the initial pass through the program. After printing information for the month, it asks whether this is the last month and, if it is not, it then asks whether there are revisions for the next month. The process is repeated until the answer to the question "IS THIS THE LAST MONTH" is "YES", at which point the program proceeds as

before, calculating and printing grand summaries of heat loss and costs.

Once again, the program asks whether any revisions of the input are desired. If the answer is "YES", then the program recycles in the manner described above. If the answer is "NO", the program terminates with a termination statement.

Sample Program Run

The operation of the HEATCOST Computer program is probably best understood by the reference to the typewriter output from a typical timesharing session. Figure 3 gives a plan view of a hypothetical two story building whose basic dimensions are 60 feet by 100 feet. Figure 4 gives wall elevation views for the building's three exposed walls. In addition to the assumed information shown on Figures 3 and 4, it is assumed, for the initial run, that the basement floor would have a U factor of 0.045, based on the temperature difference between the inside and outside air temperatures, but that this factor will be reduced by 20 percent, to 0.036, due to insulation of the slab and foundation wall.

Exhibit E gives the complete listing from the run that analyzed the sample building depicted in Figures 3 and 4. The first eleven lines are used to sign onto the system and to call for the program which has been stored in the computer's memory. These statements will depend somewhat on the particular computer installation being used. After printing the program identification, the program asks for identification of the project, which the analyst has then typed after the "=" sign; this information is then typed immediately thereafter by the

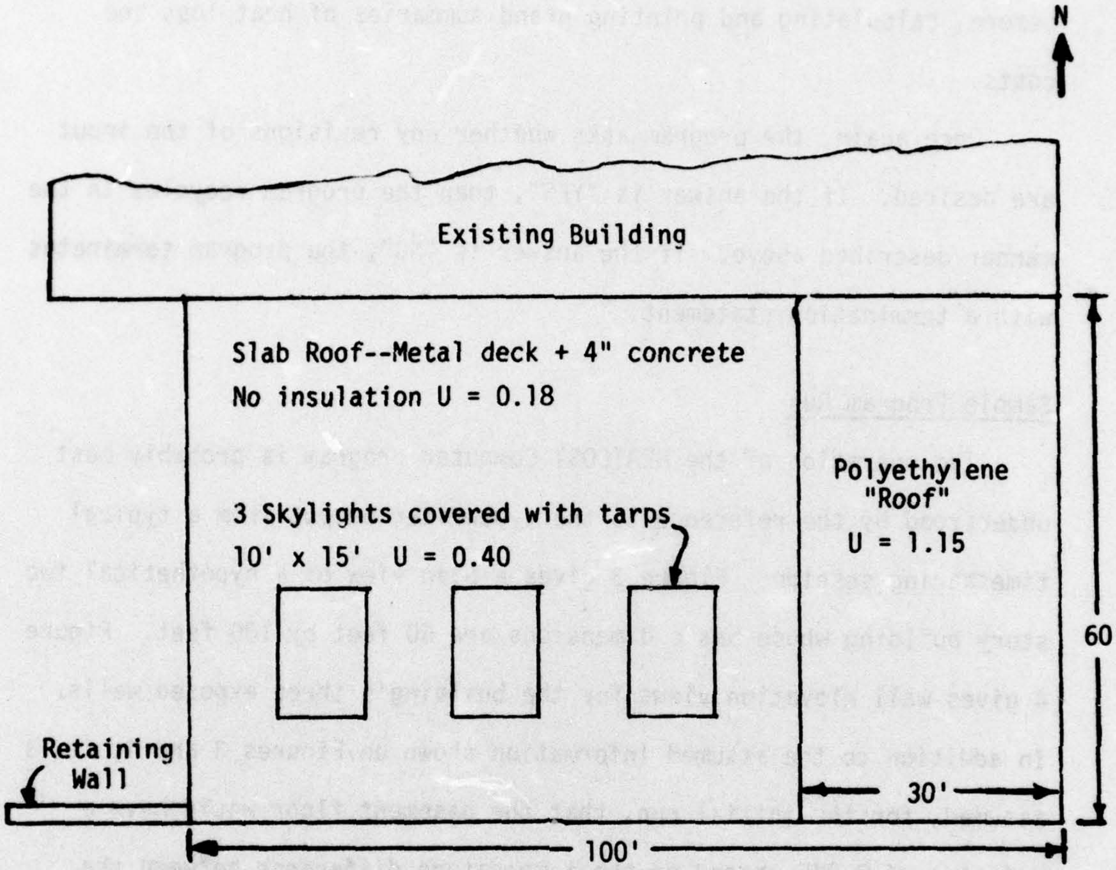

Figure 3. Hypothetical Two-Story Building--Plan View

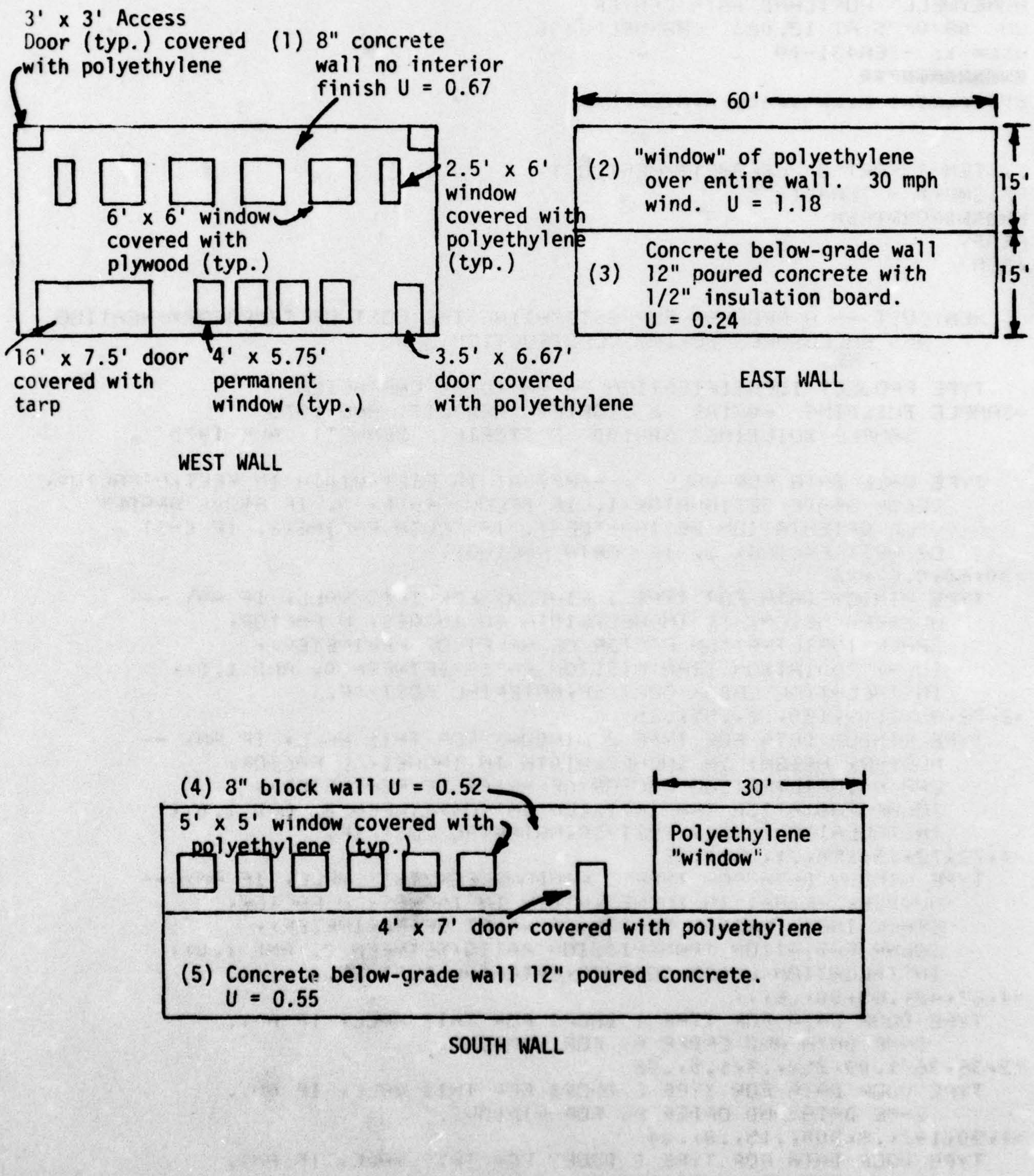

Figure 4. Hypothetical Two-Story Building--Elevation Views

EXHIBIT E. Keyboard Listing for Sample Program Run

```
0310400
HONEYWELL  PORTLAND DATA CENTER
ON  08/0/75 AT 12.083  CHANNEL 2430
USER ID -SEA431-90
[redacted]
298 BLOCKS FILE SPACE AVAILABLE

SYSTEM ?YFORT O /LBENNETT/HEATCOST
PASSWORD - SEA4310 ?
[redacted]
READY
*RUN

  HEATCOST -- A PROGRAM FOR ESTIMATING THE COST OF TEMPORARY HEATING
      AND ENCLOSURES DURING CONSTRUCTION

  TYPE PROJECT IDENTIFICATION -- UP TO 60 CHARACTERS
=SAMPLE BUILDING  60X100  2 STORIES  BENNETT  AUG 1975
       SAMPLE BUILDING  60X100  2 STORIES  BENNETT  AUG 1975

  TYPE WALL DATA FOR WALL  1 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
     BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
     WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
     OR WEST FACING, 3. IF NORTH FACING).
=30,60,0.67,,2
  TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
     NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
     CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
     SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
     INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=2,72,30,1.09,150,.8,.55,.20
  TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
     NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
     CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
     SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
     INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=4,72,72,.5,250,.1,.65,.02
  TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
     NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
     CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
     SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
     INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=4,69,48,.65,60,.6,,,
  TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=2,36,36,1.09,250,.8,1.5,.02
  TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=1,90,192,.8,300,.15,.8,.04
  TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=1,90,42,1.09,450,.8,.96,.02
  IS WALL  1 THE LAST WALL
=NO
```

```
    TYPE WALL DATA FOR WALL  2 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
       BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
       WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
       OR WEST FACING, 3. IF NORTH FACING).
=15,60,,,2
    TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,180,720,1.18,220,.85,.45,.02
    TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
    TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
    TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
        SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
    TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
        SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
    TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
        SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
    IS WALL  2 THE LAST WALL
=NO
    TYPE WALL DATA FOR WALL  3 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
       BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
       WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
       OR WEST FACING, 3. IF NORTH FACING).
=15,60,.24,1,2
    TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
    TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
    TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
    TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
        SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
```

```
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  3 THE LAST WALL
=NO
   TYPE WALL DATA FOR WALL  4 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
       BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
       WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
       OR WEST FACING, 3. IF NORTH FACING).
=15,100,.52,,1
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=6,60,60,1.09,250,.8,.65,.02
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,180,360,1.09,220,.8,.45,.02
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=1,84,48,1.09,450,.8,.96,.02
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  4 THE LAST WALL
=NO
   TYPE WALL DATA FOR WALL  5 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
       BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
       WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
       OR WEST FACING, 3. IF NORTH FACING).
=15,100,.55,,01,1
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
       NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
       CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
       SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
       INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
```

```
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
     NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
     CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
     SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
     INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  5 THE LAST WALL
=YES
                    WALL NUMBER  1
   GROSS AREA =  1800.0 SF  ,WINDOW AREA =   266.0 SF
    DOOR AREA =   161.3 SF   NET AREA =  1372.7 SF
     WINDOW COSTS--LABOR = $ 110.10   MATERIALS = $   8.88
      DOOR COSTS--LABOR = $ 145.40   MATERIALS = $  5.63
       U*A PRODUCTS--WALL =  919.7 WINDOWS =  164.5  DOORS = 141.1
        CRACK INFILTRATION PRODUCTS--WINDOWS =  608.0  DOORS = 526.5
         SOLAR RADIATION PRODUCTS--WINDOWS =   93.6  DOORS =  51.1

                    WALL NUMBER  2
   GROSS AREA =   900.0 SF  ,WINDOW AREA =   900.0 SF
    DOOR AREA =     0.  SF   NET AREA =     0.  SF
     WINDOW COSTS--LABOR = $ 405.00   MATERIALS = $  18.00
      DOOR COSTS--LABOR = $    0.    MATERIALS = $   0.
       U*A PRODUCTS--WALL =      0.   WINDOWS = 1062.0  DOORS =    0.
        CRACK INFILTRATION PRODUCTS--WINDOWS =  594.0  DOORS =    0.
         SOLAR RADIATION PRODUCTS--WINDOWS =  765.0  DOORS =    0.

                    WALL NUMBER  3
   GROSS AREA =   900.0 SF  ,WINDOW AREA =     0.  SF
    DOOR AREA =     0.  SF   NET AREA =   900.0 SF
     WINDOW COSTS--LABOR = $    0.     MATERIALS = $  0.
      DOOR COSTS--LABOR = $    0.     MATERIALS = $  0.
       U*A PRODUCTS--WALL =  216.0  WINDOWS =     0.   DOORS =    0.
        CRACK INFILTRATION PRODUCTS--WINDOWS =     0.   DOORS =    0.
         SOLAR RADIATION PRODUCTS--WINDOWS =     0.   DOORS =    0.

                    WALL NUMBER  4
   GROSS AREA =  1500.0 SF  ,WINDOW AREA =   600.0 SF
    DOOR AREA =    28.0 SF   NET AREA =   872.0 SF
     WINDOW COSTS--LABOR = $ 300.00   MATERIALS = $  12.00
      DOOR COSTS--LABOR = $  26.88   MATERIALS = $   0.56
       U*A PRODUCTS--WALL =  453.4  WINDOWS =  654.0  DOORS =  30.5
        CRACK INFILTRATION PRODUCTS--WINDOWS =  896.4  DOORS = 178.2
         SOLAR RADIATION PRODUCTS--WINDOWS =  480.0  DOORS =  22.4

                    WALL NUMBER  5
   GROSS AREA =  1500.0 SF  ,WINDOW AREA =     0.  SF
    DOOR AREA =     0.  SF   NET AREA =  1500.0 SF
     WINDOW COSTS--LABOR = $    0.     MATERIALS = $  0.
      DOOR COSTS--LABOR = $    0.     MATERIALS = $  0.
       U*A PRODUCTS--WALL =  825.0  WINDOWS =     0.   DOORS =    0.
        CRACK INFILTRATION PRODUCTS--WINDOWS =     0.   DOORS =    0.
         SOLAR RADIATION PRODUCTS--WINDOWS =     0.   DOORS =    0.
```

```
TYPE ROOF LENGTH IN FEET, WIDTH IN FEET AND U FACTOR.
=100,60,.18
   TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE 1 ENCLOSURES, IF ANY--
      NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=3,180,120,.4,230,.1,.5,.15
   TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE 2 ENCLOSURES, IF ANY--
      NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,720,360,1.15,200,.85,.45,.02


     GROSS ROOF AREA =  6000.0 SF   TEMPORARY ENCLOSURES AREA(ROOF) =
       2250.0 SF   NET ROOF AREA =  3750.0 SF
       ROOF TEMPORARY ENCLOSURES COSTS--LABOR = $1035.00   MATERIALS
        = $ 103.50
         U*A PRODUCTS--ROOF =  675.0  TEMPORARY ENCLOSURES= 2250.0
          CRACK INFILTRATION PRODUCT = 1269.0
           SOLAR RADIATION PRODUCT =  1575.0
   TYPE FLOOR U FACTOR & FACTOR BASIS DESIGNATOR(1.=U BASED ON SOIL
      TEMPERATURE, 0.=U BASED ON OUTSIDE AIR TEMPERATURE)
=0.036,0


     FLOOR AREA =  6000.0 SF    U*A PRODUCT FOR FLOOR =  216.0


   TYPE DESCRIPTION OF HEATING METHOD--UP TO 40 CHARACTERS
=SEVERAL "MASTER" TYPE 100K BTU/HR HTRS
   TYPE HEATING COST/1000 BTUS,AVERAGE INSIDE TEMPERATURE,AND MONTHLY
      COST OF MAINTAINING ENCLOSURES(AS PCT OF FIRST COST)
=.0024,60,2.5
   TEMPORARY HEATING WILL BE SEVERAL "MASTER" TYPE 100K BTU/HR HTRS
        AT A COST OF $.00240 PER 1000 BTUS
              THE ASSUMED AVERAGE INSIDE TEMPERATURE IS 60.0 DEG F
                   THE ASSUMED COST OF MAINTAINING TEMPORARY ENCLOSURES
                       IS  2.5 PERCENT OF FIRST COST PER MONTH.
   TYPE NAME OF MONTH  1
=SEPTEMBER 198504
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=30,45,40,,730,1380,715,1.3
```

```
   FOR SEPTEMBER 1984   , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
       OF  45.0 (OUTSIDE),
           40.0 (SOIL), AND
           60.0 (INSIDE),
         THE TOTAL HEAT LOSS IS 105401443. BTUS,
         THE ESTIMATED HEATING COST IS $ 252.96
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  28.22
         (BASED ON  1.30 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  1 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  2
=OCTOBER 1984
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,33.5,37,,313,1190,348,


   FOR OCTOBER 1984     , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
       OF  33.5 (OUTSIDE),
           37.0 (SOIL), AND
           60.0 (INSIDE),
         THE TOTAL HEAT LOSS IS 186008552. BTUS,
         THE ESTIMATED HEATING COST IS $ 446.42
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  54.27
         (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  2 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  3
=NOVEMBER 1984
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=30,12.3,34.6,,118,507,175,


   FOR NOVEMBER 1984    , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
       OF  12.3 (OUTSIDE),
           34.6 (SOIL), AND
           60.0 (INSIDE),
         THE TOTAL HEAT LOSS IS 313874412. BTUS,
         THE ESTIMATED HEATING COST IS $ 753.30
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  54.27
         (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  3 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  4
=DECEMBER 1984
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,-1,31,,22,404,49,
```

```
FOR DECEMBER 1984    , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
   OF   -1.0 (OUTSIDE),
        31.0 (SOIL), AND
        60.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 412583844. BTUS,
      THE ESTIMATED HEATING COST IS $ 990.20
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $   54.27
      (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  4 THE LAST MONTH
=NO
  TYPE NAME OF MONTH  5
=JANUARY 198495
  TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
     AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
     (IF DIFFERENT FROM ORIGINAL INPUT),
     SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
     SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
     MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,-12.7,30,56,63,718,112,5.3


FOR JANUARY 1985     , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
   OF -12.7 (OUTSIDE),
        30.0 (SOIL), AND
        56.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 459261380. BTUS,
      THE ESTIMATED HEATING COST IS $1102.23
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $ 115.06
      (BASED ON  5.30 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  5 THE LAST MONTH
=NO
  TYPE NAME OF MONTH  6
=FEBRUARY 1985
  TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
     AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
     (IF DIFFERENT FROM ORIGINAL INPUT),
     SOLAR RADIA)ION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
     SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
     MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=28,-5,29.2,,272,1452,342,4


FOR FEBRUARY 1985    , WHICH HAS 28. DAYS, AND AVERAGE TEMPERATURES
   OF   -5.0 (OUTSIDE),
        29.2 (SOIL), AND
        60.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 395824364. BTUS,
      THE ESTIMATED HEATING COST IS $ 949.98
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $   86.84
      (BASED ON  4.00 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  6 THE LAST MONTH
=NO
  TYPE NAME OF MONTH  7
=MARCH 1985
  TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
     AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
     (IF DIFFERENT FROM ORIGINAL INPUT),
     SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
     SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
     MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,15.5,28,,806,2095,822,3
```

```
   FOR MARCH 1985       , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
      OF   15.5 (OUTSIDE),
           28.0 (SOIL), AND
           60.0 (INSIDE),
         THE TOTAL HEAT LOSS IS 306518360. BTUS,
         THE ESTIMATED HEATING COST IS $ 735.64
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  65.13
         (BASED ON  3.00 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  7 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  8
=APRIL 1985
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=30,40,31,,1390,1721,1238,

   FOR APRIL 1985       , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
      OF   40.0 (OUTSIDE),
           31.0 (SOIL), AND
           60.0 (INSIDE),
         THE TOTAL HEAT LOSS IS 141428720. BTUS,
         THE ESTIMATED HEATING COST IS $ 339.43
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  54.27
         (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  8 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  9
=MAY 1985
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,52,34,62,1820,1310,1310,

   FOR MAY 1985         WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
      OF   52.0 (OUTSIDE),
           34.0 (SOIL), AND
           62.0 (INSIDE),
         THE TOTAL HEAT LOSS IS  90970694. BTUS,
         THE ESTIMATED HEATING COST IS $ 194.33
         AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  54.27
         (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  9 THE LAST MONTH
=YES
```

```
TOTAL BTUS LOST ARE AS FOLLOWS--
     WALLS                              541184112.
     WINDOWS                            488901420.
     DOORS                               44606459.
     FLOOR                               56156717.
     ROOF                               175489740.
     ROOF ENCLOSURES                    584965800.
     WINDOW CRACKS                      272781252.
     DOOR CRACKS                         91605644.
     ROOF ENCLOSURES CRACKS             164960356.
     SOLAR HEAT GAIN (MINUS)             18779721.

          TOTAL                             2401871776.

TOTAL ESTIMATED COSTS ARE AS FOLLOWS--
          TEMPORARY ENCLOSURES INSTALLATION      $ 2170.95
          HEATING                                $ 5764.49
          TEMPORARY ENCLOSURES MAINTENANCE       $  566.62

               TOTAL                             $ 8502.06

   DO YOU WISH TO REVISE SOME INPUT DATA
=YES
        SAMPLE BUILDING  60X100  2 STORIES  BENNETT  AUG 1975

   ARE THERE ANY WALL DATA REVISIONS FOR WALL  1
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 1 DATA IN WALL  1
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 2 DATA IN WALL  1
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 3 DATA IN WALL  1
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 1 DATA IN WALL  1
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 2 DATA IN WALL  1
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 3 DATA IN WALL  1
=NO
   IS WALL  1 THE LAST WALL
=NO
   ARE THERE ANY WALL DATA REVISIONS FOR WALL  2
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 1 DATA IN WALL  2
=YES
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,180,720,.75,220,.85,.65,.11
   ARE THERE ANY REVISIONS TO WINDOW TYPE 2 DATA IN WALL  2
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 3 DATA IN WALL  2
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 1 DATA IN WALL  2
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 2 DATA IN WALL  2
=NO
```

```
   ARE THERE ANY REVISIONS TO DOOR TYPE 3 DATA IN WALL  2
=NO
   IS WALL  2 THE LAST WALL
=NO
   ARE THERE ANY WALL DATA REVISIONS FOR WALL  3
=YES
   TYPE WALL DATA FOR WALL  3 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
      BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
      WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
      OR WEST FACING, 3. IF NORTH FACING).
=15,60,.43,1,2
   ARE THERE ANY REVISIONS TO WINDOW TYPE 1 DATA IN WALL  3
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 2 DATA IN WALL  3
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 3 DATA IN WALL  3
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 1 DATA IN WALL  3
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 2 DATA IN WALL  3
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 3 DATA IN WALL  3
=NO
   IS WALL  3 THE LAST WALL
=NO
   ARE THERE ANY WALL DATA REVISIONS FOR WALL  4
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 1 DATA IN WALL  4
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 2 DATA IN WALL  4
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 3 DATA IN WALL  4
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 1 DATA IN WALL  4
=YES
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=1,84,48,.85,200,.4,.96,.12
   ARE THERE ANY REVISIONS TO DOOR TYPE 2 DATA IN WALL  4
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 3 DATA IN WALL  4
=NO
   IS WALL  4 THE LAST WALL
=NO
   ARE THERE ANY WALL DATA REVISIONS FOR WALL  5
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 1 DATA IN WALL  5
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 2 DATA IN WALL  5
=NO
   ARE THERE ANY REVISIONS TO WINDOW TYPE 3 DATA IN WALL  5
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 1 DATA IN WALL  5
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 2 DATA IN WALL  5
=NO
   ARE THERE ANY REVISIONS TO DOOR TYPE 3 DATA IN WALL  5
=NO
   IS WALL  5 THE LAST WALL
=YES
```

```
              WALL NUMBER  1
GROSS AREA =  1800.0 SF  ,WINDOW AREA =   266.0 SF
 DOOR AREA =   161.3 SF   NET AREA =  1372.7 SF
  WINDOW COSTS--LABOR = $ 110.10   MATERIALS = $   8.88
   DOOR COSTS--LABOR = $ 145.40   MATERIALS = $   5.63
    U*A PRODUCTS--WALL = 919.7  WINDOWS =  164.5  DOORS = 141.1
     CRACK INFILTRATION PRODUCTS--WINDOWS =  608.0  DOORS = 526.5
      SOLAR RADIATION PRODUCTS--WINDOWS =   93.6  DOORS =  51.1

              WALL NUMBER  2
GROSS AREA =   900.0 SF  ,WINDOW AREA =   900.0 SF
 DOOR AREA =     0.  SF   NET AREA =     0.  SF
  WINDOW COSTS--LABOR = $ 585.00   MATERIALS = $  99.00
   DOOR COSTS--LABOR = $   0.     MATERIALS = $   0.
    U*A PRODUCTS--WALL =    0.   WINDOWS =  675.0  DOORS =  0.
     CRACK INFILTRATION PRODUCTS--WINDOWS =  594.0  DOORS =   0.
      SOLAR RADIATION PRODUCTS--WINDOWS =  765.0  DOORS =   0.

              WALL NUMBER  3
GROSS AREA =   900.0 SF  ,WINDOW AREA =     0.  SF
 DOOR AREA =     0.  SF   NET AREA =   900.0 SF
  WINDOW COSTS--LABOR = $   0.     MATERIALS = $   0.
   DOOR COSTS--LABOR = $   0.     MATERIALS = $   0.
    U*A PRODUCTS--WALL =  387.0  WINDOWS =     0.    DOORS =   0.
     CRACK INFILTRATION PRODUCTS--WINDOWS =    0.   DOORS =   0.
      SOLAR RADIATION PRODUCTS--WINDOWS =    0.   DOORS =   0.

              WALL NUMBER  4
GROSS AREA =  1500.0 SF  ,WINDOW AREA =   600.0 SF
 DOOR AREA =    28.0 SF   NET AREA =   872.0 SF
  WINDOW COSTS--LABOR = $ 300.00   MATERIALS = $  12.00
   DOOR COSTS--LABOR = $  26.88   MATERIALS = $   3.36
    U*A PRODUCTS--WALL =  453.4  WINDOWS =  654.0  DOORS =  23.8
     CRACK INFILTRATION PRODUCTS--WINDOWS =  896.4  DOORS =  79.2
      SOLAR RADIATION PRODUCTS--WINDOWS =  480.0  DOORS =  11.2

              WALL NUMBER  5
GROSS AREA =  1500.0 SF  ,WINDOW AREA =     0.  SF
 DOOR AREA =     0.  SF   NET AREA =  1500.0 SF
  WINDOW COSTS--LABOR = $   0.     MATERIALS = $   0.
   DOOR COSTS--LABOR = $   0.     MATERIALS = $   0.
    U*A PRODUCTS--WALL =  825.0  WINDOWS =     0.   DOORS =   0.
     CRACK INFILTRATION PRODUCTS--WINDOWS =    0.   DOORS =   0.
      SOLAR RADIATION PRODUCTS--WINDOWS =    0.   DOORS =   0.

   ARE THERE ANY REVISIONS TO ROOF DATA
=NO
   ARE THERE ANY REVISIONS TO ROOF ENCLOSURE TYPE 1 DATA
=NO
   ARE THERE ANY REVISIONS TO ROOF ENCLOSURE TYPE 2 DATA
=YES
   TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE 2 ENCLOSURES, IF ANY--
      NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,720,360,.63,125,.05,.45,.22
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GROSS ROOF AREA =  6000.0 SF   TEMPORARY ENCLOSURES AREA(ROOF) =
  2250.0 SF   NET ROOF AREA =  3750.0 SF
  ROOF TEMPORARY ENCLOSURES COSTS--LABOR = $1035.00   MATERIALS
   = $ 463.50
    U*A PRODUCTS--ROOF =  675.0  TEMPORARY ENCLOSURES= 1314.0
     CRACK INFILTRATION PRODUCT = 1026.0
      SOLAR RADIATION PRODUCT =    135.0
  ARE THERE ANY REVISIONS TO FLOOR DATA
=YES
  TYPE FLOOR U FACTOR & FACTOR BASIS DESIGNATOR(1.=U BASED ON SOIL
     TEMPERATURE, 0.=U BASED ON OUTSIDE AIR TEMPERATURE)
=0.036,1


 FLOOR AREA =  6000.0 SF    U*A PRODUCT FOR FLOOR =  216.0


  ARE THERE REVISIONS TO HEATING METHOD DESCRIPTION
=NO
  ARE THERE ANY REVISIONS TO HEATING COST, INSIDE TEMPERATURE
     OR MAINTENANCE COST
=NO
  TEMPORARY HEATING WILL BE SEVERAL "MASTER" TYPE 100K BTU/HR HTRS
       AT A COST OF $.00240 PER 1000 BTUS
           THE ASSUMED AVERAGE INSIDE TEMPERATURE IS 60.0 DEG F
                THE ASSUMED COST OF MAINTAINING TEMPORARY ENCLOSURES
                     IS  2.5 PERCENT OF FIRST COST PER MONTH.
  ARE THERE ANY REVISIONS TO MONTH  1 DATA
=NO

  FOR SEPTEMBER 1984  , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
     OF  45.0 (OUTSIDE),
         40.0 (SOIL), AND
         60.0 (INSIDE),
       THE TOTAL HEAT LOSS IS  93500323. BTUS,
       THE ESTIMATED HEATING COST IS $ 224.40
       AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  36.33
       (BASED ON  1.30 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  1 THE LAST MONTH
=NO
  ARE THERE ANY REVISIONS TO MONTH  2 DATA
=NO

  FOR OCTOBER 1984    , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
     OF  33.5 (OUTSIDE),
         37.0 (SOIL), AND
         60.0 (INSIDE),
       THE TOTAL HEAT LOSS IS 159248092. BTUS,
       THE ESTIMATED HEATING COST IS $ 382.20
       AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  69.87
       (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  2 THE LAST MONTH
=NO
  ARE THERE ANY REVISIONS TO MONTH  3 DATA
=NO
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```
   FOR NOVEMBER 1984    , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
      OF  12.3 (OUTSIDE),
          34.6 (SOIL), AND
          60.0 (INSIDE),
        THE TOTAL HEAT LOSS IS 262168434. BTUS.
        THE ESTIMATED HEATING COST IS $ 629.20
        AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  69.87
        (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  3 THE LAST MONTH
=NO
   ARE THERE ANY REVISIONS TO MONTH  4 DATA
=NO


   FOR DECEMBER 1984    , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
      OF  -1.0 (OUTSIDE),
          31.0 (SOIL), AND
          60.0 (INSIDE).
        THE TOTAL HEAT LOSS IS 343058340. BTUS,
        THE ESTIMATED HEATING COST IS $ 823.34
        AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  69.87
        (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  4 THE LAST MONTH
=NO
   ARE THERE ANY REVISIONS TO MONTH  5 DATA
=YES
   TYPE NAME OF MONTH  5
=JANUARY 1985
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,-12.7,30,56,63,718,112,3.5

   FOR JANUARY 1985     , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
      OF -12.7 (OUTSIDE),
          30.0 (SOIL), AND
          56.0 (INSIDE),
        THE TOTAL HEAT LOSS IS 379099904. BTUS,
        THE ESTIMATED HEATING COST IS $ 909.84
        AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  97.82
        (BASED ON  3.50 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  5 THE LAST MONTH
=NO
   ARE THERE ANY REVISIONS TO MONTH  6 DATA
=YES
   TYPE NAME OF MONTH  6
=FEBRUARY 1985
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=28,-5,29.2,45,272,1452,342,4
```

```
FOR FEBRUARY 1985    , WHICH HAS 28. DAYS, AND AVERAGE TEMPERATURES
    OF  -5.0 (OUTSIDE),
         29.2 (SOIL), AND
         45.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 245455364. BTUS,
      THE ESTIMATED HEATING COST IS $ 589.09
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $ 111.79
      (BASED ON  4.00 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  6 THE LAST MONTH
=NO
  ARE THERE ANY REVISIONS TO MONTH  7 DATA
=NO


FOR MARCH 1985       , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
    OF  15.5 (OUTSIDE),
         28.0 (SOIL), AND
         60.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 260078994. BTUS,
      THE ESTIMATED HEATING COST IS $ 624.19
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  83.84
      (BASED ON  3.00 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  7 THE LAST MONTH
=NO
  ARE THERE ANY REVISIONS TO MONTH  8 DATA
=NO


FOR APRIL 1985       , WHICH HAS 30. DAYS, AND AVERAGE TEMPERATURES
    OF  40.0 (OUTSIDE),
         31.0 (SOIL), AND
         60.0 (INSIDE),
      THE TOTAL HEAT LOSS IS 126809388. BTUS,
      THE ESTIMATED HEATING COST IS $ 304.34
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  69.87
      (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  8 THE LAST MONTH
=NO
  ARE THERE ANY REVISIONS TO MONTH  9 DATA
=NO


FOR MAY 1985         , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
    OF  52.0 (OUTSIDE),
         34.0 (SOIL), AND
         62.0 (INSIDE),
      THE TOTAL HEAT LOSS IS  78895753. BTUS,
      THE ESTIMATED HEATING COST IS $ 189.35
      AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $  69.87
      (BASED ON  2.50 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  9 THE LAST MONTH
=YES
```

```
TOTAL BTUS LOST ARE AS FOLLOWS--
          WALLS                        545392360.
          WINDOWS                      373232824.
          DOORS                         41197640.
          FLOOR                         36041242.
          ROOF                         168685740.
          ROOF ENCLOSURES              328374908.
          WINDOW CRACKS                262205114.
          DOOR CRACKS                   75683669.
          ROOF ENCLOSURES CRACKS       128201162.
          SOLAR HEAT GAIN (MINUS)       10690059.

                    TOTAL                       1948314592.


TOTAL ESTIMATED COSTS ARE AS FOLLOWS--
                    TEMPORARY ENCLOSURES INSTALLATION          $ 2794.75
                    HEATING                                    $ 4675.96
                    TEMPORARY ENCLOSURES MAINTENANCE           $  679.12

                              TOTAL                            $ 8149.83

   DO YOU WISH TO REVISE SOME INPUT DATA
=NO
   VERY WELL. THE ANALYSIS TERMINATES HERE.  **

*BYE


CHANNEL 2570
USER STATUS ON AUG 8,1975 AT 14:14:43  LOG-ON AT 12:56:32
PROC TIME USED  9.68 SEC., 42 DISC I/O
LIST OF OPEN FILES: HEATCOST


CP DISCONNECTS.
```

program. It should be noted that an "=" sign is always typed in the first column of the page when the program is expecting the user to provide some input data.

The command requesting wall data for wall one is followed by the analyst's response with 30, 60, 0.67,,2. The 30 is the height of wall one in feet, and the 60 is its length in feet. The 0.67 is the U factor for this concrete wall, and the 2 indicates that this wall faces east or west. Note that all numeric input data are separated with commas, and that if a particular piece of data is to be omitted two commas are given in succession with no data between. Thus for wall data for wall one the below grade designator is equal to zero; since a zero value need not be supplied, the space following the U factor value of 0.67 is occupied by two successive commas.

The program then asks for window data for type one windows for this wall, if any, and the information is supplied, as follows: 2, 72, 30, 1.09, 150, .8, .55, .20. In order, these data elements indicate the number of type one windows (2), the height in inches (72), the width in inches (30), the U factor (1.09), the crack infiltration factor (150), the solar radiation transmission ratio (.8), and the installation labor cost and material cost per square foot (.55 and .20). The program then asks for window data for the second type of windows for this wall, if any, and the data are supplied, as are those pieces of data for type three windows for this wall.

Following input of window data for the first wall, the program requests information for doors of type one, two and three, if any, and these data are supplied for this particular example. For example, the third type of doors has data values of 1, 80, 42, 1.09, 450, .8, .96 and .02.

The program then asks whether wall one is the last wall, and the analyst responds with "NO". The program then counters by requesting wall data for wall two, and the response is the following: 15, 60,,, 2. These data mean that wall two is 15 by 60 feet in area; that a value of zero is being supplied for the U factor, since the entire wall will be considered as a window because it is assumed to be completely covered with a polyethylene sheet; the wall is located above grade; and the wall is east- or west-facing. For information on window type one for this wall, the data indicate that there is one window of size 180 inches by 720 inches, thus corresponding to the total dimension of the wall itself. In response to the request for window data for type two and three windows for this wall, the analyst has typed seven commas after each "=" sign, thus separating the eight pieces of blank data for each. Requests for the three types of door data for this wall are similarly met with seven commas each. Since wall two is not the last wall, the answer to the question is "NO," and the program requests wall data for wall three plus window and door information. In this case, there are neither windows nor doors in this wall since it is below grade; thus each request results in a series of seven commas.

The process is repeated for walls four and five as indicated in the typewriter listing, until the question "IS WALL 5 THE LAST WALL". Since the answer is "YES," the program then responds by calculating and typing output for each of the five walls. Note, for example, the output for wall two. This is a special case in which the window area is equal to the gross area, since the entire wall is covered by a single polyethylene sheet. Thus the net area of the wall is calculated as zero. Costs are given for both labor and materials for windows as

are the (U factor) x (area product) for windows, the crack infiltration product for windows and the solar radiation product for windows.

Following completion of wall calculations, the program asks the analyst to type roof dimensions and roof U factor. In the example, a length of 100 feet, a width of 60 feet, and a U factor of 0.18 are used. The program then asks for the roof temporary enclosure data for each of two types of enclosures, if any. It is noted that the sample building has three roof enclosures of dimensions 180 by 120 inches whose U factor is taken as 0.4, whose crack infiltration factor is 230, whose solar radiation transmission ratio is 0.1 and whose installation labor cost and material cost are $.50/sf and $.15/sf, respectively, and one temporary enclosure in the roof whose dimensions are 720 by 360 inches, whose U factor is 1.15, whose crack infiltration factor is 200, whose solar radiation transmission ratio is 0.85 and whose labor and material cost per square foot are $.45 and $.02, respectively. After receiving input on roof and roof enclosures, the program prints gross roof area, temporary enclosures area for the roof, and net roof area. It also prints roof temporary enclosures cost for labor and materials, U factor times area products for the roof and roof temporary enclosures, crack infiltration product for roof temporary enclosures and solar radiation product for roof temporary enclosures.

The program then asks that the U factor and the U factor basis designator be given for the floor. In this example, the floor U factor is taken as 0.036; since this factor is based on outside air temperature, a zero, rather than a one, is used for the factor basis designator. Following input of floor data, the program calculates and prints floor area and the U factor times area product for the floor.

The program then requests that a description of the heating method be typed, and the analyst has responded with the description "SEVERAL 'MASTER' TYPE 100K BTU/HR HEATERS." Then, the program asks for the heating costs per 1000 BTUs, the average inside temperature and the monthly cost of maintaining enclosures. The analyst has supplied values of $.0024 per 1000 BTUs heating cost, 60°F for inside temperature and 2.5% as the monthly cost of maintaining enclosures. The program then prints out the information that has just been supplied.

The program then asks that the name of the first month be typed and the analyst responds with "SEPTEMBER 1985." Since the date should have been 1984, a single "@" sign is placed directly after the "5" and a "4" is typed. (In general, one "@" sign is used for each preceding character that the analyst wishes to change.) The program then requests the number of days in the month, the average outside temperature, the average soil temperature, the average inside temperature if it is different from that supplied with the original input, solar radiation values for the month and maintenance cost percentage if it is different from the original input. In the example for September, the values given are 30 for the number of days, 45°F for the average outside temperature, 40°F for the average soil temperature, nothing for the average inside temperature (note the two commas appearing adjacent to each other indicating no data or that the average inside temperature is taken as 60°F from the original input), solar radiation values for this location of 730 BTU's per square foot on horizontal surfaces, 1380 BTU's per square foot on vertical south-facing and 715 BTU's per square foot on vertical east- or west-facing surfaces, and a monthly maintenance cost of 1.3% of initial installation cost, rather than the 2.5% given

originally. After receiving input data for September 1984, the program repeats some of the input and then calculates and prints estimated heat loss and estimated costs of heating and enclosures maintenance. Note that in September 1984 for the sample project, the estimated heat loss is 105,401,443 BTU's, and the estimated costs of heating and enclosures maintenance are $252.96 and $28.22, respectively.

The program then asks whether the first month is the last one and, receiving the response "NO," asks for data on the second month. Note that for October 1984, the average inside temperature of 60°F will be used (thus, 2 commas are given between the data values 37 and 313), and the "standard" value of 2.5% for maintenance cost percentage will be used (thus, there is a blank following the last comma). The program performs calculations for October 1984 and prints the results; it then continues in a similar fashion for each of a total of nine months, through May, 1985. Note that the input data indicate that it is expected that the inside temperature in January will be 56°F, rather than the standard 60°F, and that inside temperature in May is estimated to be 62°F. Note also the typing error in the name of January, 1985, which was corrected by the use of the "@" sign.

Following the "YES" response to the "IS MONTH 9 THE LAST MONTH" question, the program calculates and prints summaries of heat losses through the various building elements and the gain due to solar radiation, with a total heat loss over the nine months of 2,401,871,776 BTU's for this sample project. It also prints the estimated costs of enclosure installation, heating and enclosure maintenance, and the total estimated cost, which is $8502.06 for this example.

In response to the question regarding the desire to revise some input data, the analyst has typed "YES." This indicates that revised data will be supplied, and the revision procedure begins with the typing out of the original project description. A review of the typewriter listing for the revision process indicates that no changes were desired for wall, window or door data for wall number one.

For wall number two, revisions were desired for type one window data. Thus, all eight data elements must be supplied, even though not all represent changes to the input given during the initial pass. A comparison with the original input indicates that the analyst wished to change the U factor from 1.17 to 0.75, the labor cost from $0.45 to $0.65 per square foot, and the material cost from $0.02 to $0.11 per square foot. This change is representative of the type which can analyze the overall effect on costs of a more expensive covering material that has more favorable heat loss characteristics.

For wall three, the wall data were changed, with the U factor now 0.43 instead of 0.24. In this case, the analyst could study the effect of delaying installation of insulation on the below grade wall until after the cold weather period or of using a different quality temporary insulation during this period.

For wall four, it is noted that some data for the first type of doors were changed. And for wall five, none of the data was revised. It should be emphasized that, in the absence of revision data, the program utilizes data originally input during the initial pass through the program.

After receiving the "YES" response to the query "IS WALL 5 THE LAST WALL," the program calculates and prints revised information on each wall, its windows and its doors.

Following this, revisions to data on the roof and its temporary enclosures are considered. For the sample project, revisions were not desired for the roof itself or the first type of enclosures. However, some revision to type 2 temporary enclosures were supplied. Output related to the roof was then printed, as shown.

It was decided to revise the floor data when it was realized that the U factor should be based on the difference between inside temperature and soil temperature rather than on the difference between inside temperature and outside air temperature. Thus, the revised input reads 0.036, 1 rather than 0.036,. The floor area and its (U factor) x (area) product are then printed.

Neither the description of the heating method nor the data on heating cost, inside temperature or maintenance cost are to be revised, and thus the program prints out, and uses, the data as originally supplied.

Next, the program steps through each month in turn, asking whether there are revisions to the originally-supplied data. If there are not, it uses the initial data, calculates pertinent information and prints a summary for the month. If some data are to be revised, all the data for the month must be given, the calculation and printing then proceed. In the sample, revisions are supplied to data for the months of January and February 1985. For January, a maintenance cost percent of 3.5% replaces the 5.3% value given incorrectly in the original analysis. For February, the new assumption is that the inside temperature will average 45°F, rather than 60°F as originally input.

Following the printing of output for May 1985 and the response that this is the last month, the program calculates and prints summary information on heat loss and costs for the entire period under study, as it had done after the first pass. It is interesting to note that, although the proposed alternate scheme represented by the revised data is expected to have higher installation and maintenance costs ($2794.75 vs. $2179.95 for installation; $679.12 vs. $566.62 for maintenance) the heat loss and its associated costs will be reduced sufficiently ($4675.96 vs. $5764.49) to give an overall cost that is about $350 less than the original arrangement ($8149.83 vs. $8502.06).

If any further revisions to the input were desired, the analyst could respond in that manner, and the process would be repeated again. However, in the sample case, it was decided to terminate the run by typing "NO" in response to the final question.

Following the typing of "BYE" to disconnect the terminal from central processing unit, the terminal prints summary time use data and then the final message, "CP DISCONNECTS."

The complete run described in this section required approximately 43 minutes of time at the terminal, while the terminal was connected to the central processing unit. However, only 9.68 seconds of actual processing time were used. At a rate of $0.45 per second of processing time, the total computer cost for this analysis was approximately $4.50.

Program Validation

To determine how closely the HEATCOST program might estimate actual heat loss in a building under construction, the program was applied to an already completed project, the Laboratory Building

Addition at the University of Alaska, Fairbanks, Alaska. Temporary enclosures and heating of this project during its construction had previously been studied during the winter of 1973-74, under grant no. DA-ENG-27021-3-G45 from the U.S. Army Cold Regions Research and Engineering Laboratory. The final report, published as CRREL Special Report , is entitled "Temporary Enclosures and Heating During Construction: A Case Study of the Laboratory Building Addition, University of Alaska." (1) Figure 5 shows the Laboratory Building Addition after completion.

As part of that research project, a complete record of temperatures both inside the first floor and outside the building was maintained during that portion of the construction period between mid-January and the end of April 1974. In addition, a record of heating required to maintain the recorded inside temperature was kept from January 26 through April 15, 1974. During the winter period, only the first floor of the three story building was maintained at a warm enough temperature that work could proceed. Work did go on at this level at low outside temperatures, even when outside temperature reached as low as -44°F, on January 28, 1974.

To validate the program, then, it was necessary to determine heat loss and gain characteristics of the various building elements and to supply these to the program, together with temperature data, in a fashion explained in previous sections of this report. The result was an estimate of BTU's used during each of the four months when the heating record was maintained; this estimate could then be compared with actual data to determine how well the program determines estimated total heat loss.

Figure 5. Laboratory Building Addition Project, After Completion

Figure 6 gives a first floor plan view of the Laboratory Building Addition project, with the four different wall segments, as input to the program, designated. In the discussion below, insulation values are taken from the ASHRAE guide (2), crack infiltration factors are based on the approach suggested by Jennings (5), floor insulation is based on tables from Down (3), and solar radiation transmissions are based on date given in Mirth (6).

<u>Wall Number One</u>

Location - south, below grade
Basic dimensions: length = 134.91 ft; height = 18.0 ft; width = 12.5" average
For R value use .96 for concrete wall, 14.8 for 4" thick rigid insulation, and .68 for inside air film.
Combined R = .96 + 14.8 + .68 = 16.44; therefore

$$U = \frac{1}{16.44} = .061.$$

<u>Wall Number Two</u>

Location - east, below grade
Basic dimensions: length = 30.67 ft; height = 18.0 ft; width = 12.5" average
U factor = 0.061, similar to wall number one above.

<u>Wall Number Three</u>

Location - above grade, east
Basic dimensions: length = 41.00 ft; height = 18.0 ft; precast panel thickness = 4" + 4" rigid insulation.
For R factor use 0.17 for outside air film, 0.32 for precast panel, 14.8 for 4" insulation and 0.68 for inside air film.
Combined R = 0.17 + 0.32 + 14.8 + 0.68 = 15.97; therefore

$$U = \frac{1}{15.97} = 0.063.$$

Assume a 5 mph wind, but the wind correction is negligible.

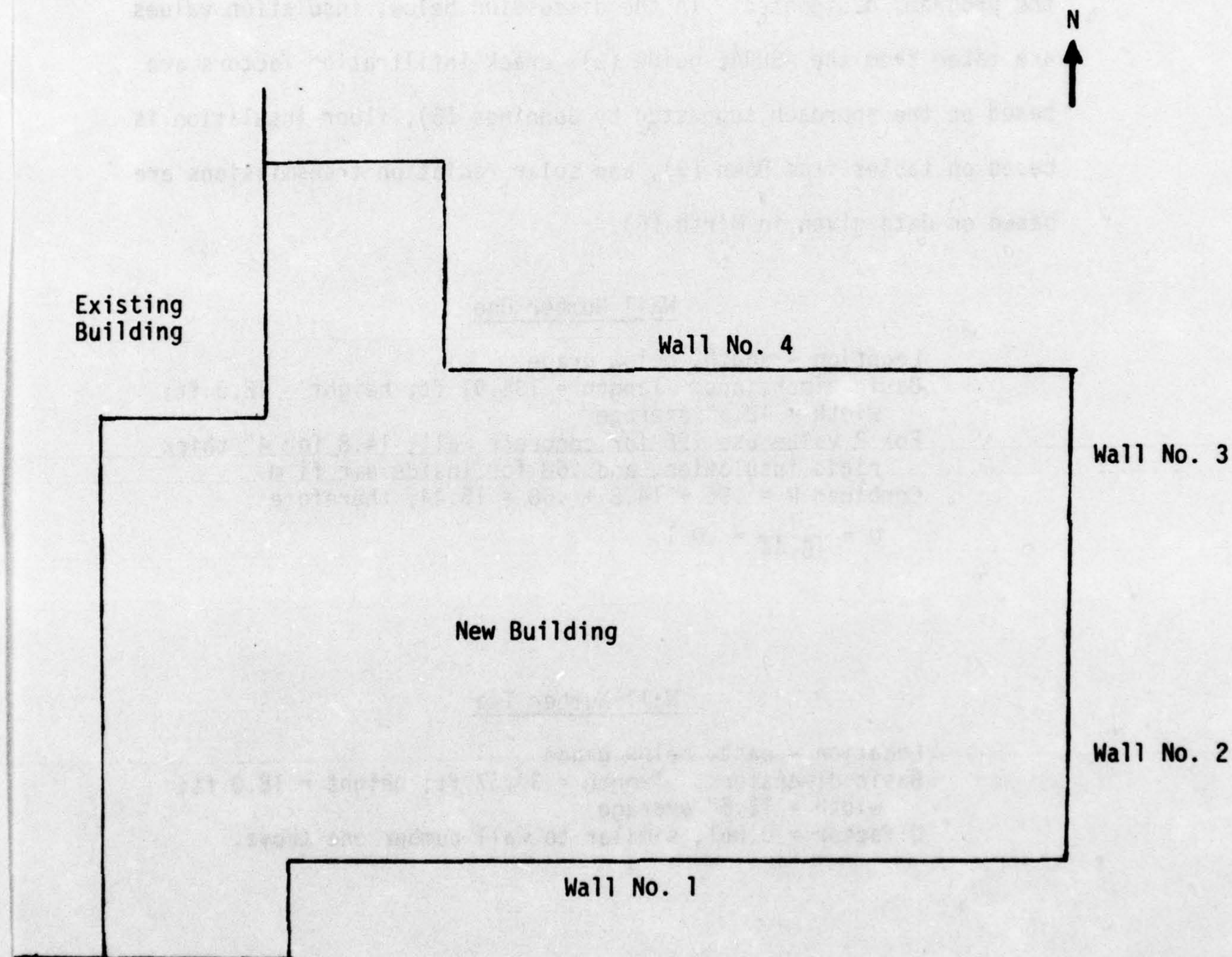

Figure 6. Laboratory Building Addition--First Floor Plan View

There are three windows, each with dimensions 48 in. by 75 in. covered with polyethylene sheeting. For windows use a basic U factor of 1.09, reduced to 0.93 to include the effect of a 5 mph wind. For these windows assume a crack infiltration factor of 750 cubic ft./hr/ft. of crack. There is one "window" of dimensions 120 in. by 216 in. a large polyethylene sheet placed over the entire height of the wall for a ten foot length. For this window, use a U factor of 0.93, a crack infiltration factor of 1,000 cubic feet per hr/ft. of crack (this "window" was ripped part of the time), and a solar radiation transmission factor of 0.85. There is one door of dimensions 36" by 84", covered with polyethylene sheeting. Use a U factor of 0.93, a crack infiltration factor of 1500, to include the effect of opening the door, and a solar radiation transmission factor of 0.85.

<u>Wall Number Four</u>

Location - above grade, north side
Basic dimensions: length = 84.0 ft; height = 18.0 ft; this wall consists of 4" thick precast concrete panels with 4" thick rigid insulation, similar to wall number three.
Use wall U factor of 0.063, as for wall number three.

There are six windows of dimensions 48 in. by 75 in, covered with the same materials as those in wall number three. Therefore, use U factor, crack infiltration

factor and solar radiation transmission ratio values similar to those for the three windows of identical dimensions in wall number three. There is one door of dimensions 72 in. by 84 in., covered with polyethylene sheeting. Use U factor, crack infiltration factor and solar radiation transmission radiation values identical to those given for the door in wall number three.

Roof

Basic dimensions: 108.25 ft. by 71.67 ft.
Roof for the first floor is the second floor slab, which consists of a four inch thick uninsulated concrete slab.
For the roof R factor use 0.17 for outside air, 0.32 for the concrete slab and 0.61 for the inside air film. Therefore, the combined R factor is $0.17 + 0.32 + 0.61 = 1.1$;
U factor $= \frac{1}{1.1} = 0.909$

The western portion of the roof contained an "enclosure," consisting of metal decking with approximately one inch of fiber glass insulation, covered with a plywood sheet. Basic dimensions of the enclosure were 26.91 ft. by 75.0 ft. For the R factor, use 0.17 for outside air, 0.63 for the plywood sheet, 2.62 for the fiberglass, 0 for the deck, and 0.61 for the inside air film. Therefore the combined R $= .17 + .162 + 2.62 + 0.61 = 4.03$; U factor $= \frac{1}{4.03} = .242$. Use a crack infiltration factor of 1000, and a solar radiation transmission factor of 0.

Floor

The floor is a four inch thick concrete slab on grade of dimensions 108.25 ft. by 71.67 ft. A two inch thick sheet of vertical rigid insulation was installed on the foundation wall from the floor slab down to the top of the footing. For the U factor based on difference between inside and outside air temperature, use the average of 0.055, the suggested factor for a slab with four edges exposed and 0.032, the suggested factor for a slab with two edges exposed, or 0. 044. (3) This factor should be reduced by 19% for insulation extending to 40 inches. Therefore the U factor is 0.036, based on the difference between inside and outside air temperatures.

Costs

For all temporary enclosures, it is desirable to supply the program with an estimate of the cost per square foot of each type of enclosure. Beginning early in the Laboratory Building Addition project, large portions of the building were enclosed with polyethylene sheeting and other types of enclosures. Later, as wall panels were erected, these temporary enclosures were removed, and smaller enclosures were fitted over window openings. During the period for which temperature and heating information is available, most of the walls had been enclosed with precast panels; the wall data given previously represent these later conditions. Thus, a great deal of the cost involved in supplying and erecting temporary enclosures had already been spent prior to the time for which this validation study is being made. Therefore, any cost estimated by the computer program based on unit costs of enclosures, will be much less than the actual costs for the total construction period, as reported in the final report on the case study project.

Nonetheless, to provide some representative cost input, the following elements have been developed;

For materials: Total material cost = $570.00
Total area of materials = 17,555 sq. ft.
Unit cost = $0.0325/sq. ft.

For labor: Total installation cost = $4,000
Total area = 17,555 sq. ft.
Unit cost = $0.2278/sq. ft.

For maintenance: Assume the $190 for removal is the maintenance cost. Therefore, since the total installation cost is $4,570 the maintenance cost will be $\frac{190}{4570} \times 100 = 4.157\%$ for 4 months, or 1.04% per month.

For heating costs:

Space heater costs--charge one month @ $260	= $ 260
For steam heaters, the equivalent cost	= 640
For space heater fuel	
18 days @ 18 hr/day x 3.5 gal/hr = 1134 gallons	
17 days @ 10 hr/day x 2.6 gal/hr. = 442 gallons	
Total gallons = 1576 @ $0.40	= 630
For wiring and starters,	= 150
For steam,	= 3660
For electricity,	= 100
	$5440

Total BTU's lost during the period from January 26 to April 15, 1974 was 1,251,291,000 x 10^3 BTU's. Therefore an estimate of the heating cost is

$$\frac{\$5,440}{1,251,291,000} = \$0.00434/1000 \text{ BTU's}.$$

Other Data

In Table V, the balance of the required data used as input to the HEATCOST program, to validate the program, is given. Inside and outside air temperatures are based on the previous Laboratory Building Addition study, soil temperatures are estimated, and solar radiation

values are for the number of days included in the period, based on the Mirth paper (6).

Results of Validation Computer Run

Appendix III contains the complete keyboard listing from the time-sharing session that analyzed the expected heat loss from the Laboratory Building Addition project, based upon the input values discussed above. The last section from that output is repeated as Table VI.

A comparison of heat loss per month predicted by the program with that actually recorded on the project is given in Table VII. Although the heat loss estimated by the program for the total time being studied is somewhat less than that actually recorded (83.9%), it is believed that the program has actually done a good job of predicting actual heat loss. For the end of January and the total month of February, the predictions are remarkably close to the amounts actually recorded and are well within any estimating accuracy that would be expected for a construction project. (In fact, they may be questioned as being too accurate to be legitimate!)

The rather low estimates in March and April, and especially the estimate that is 38.8% of actual for the first half of April, can be explained rather easily. Toward the end of March and especially in April, with the coming of warmer weather, some enclosures were removed and doors were frequently left open even though heat continued to be supplied within the building. The project diary shows several occasions when various openings were not covered, at least during the

TABLE VI. Grand Summary from Validation Run

Total BTU's Lost Are As Follows--

Walls	15.9×10^6
Windows	36.7
Doors	5.7
Floor	27.2
Roof	507.4
Roof Enclosures	48.7
Window Cracks	170.2
Door Cracks	60.4
Roof Enclosure Cracks	178.5
Solar Heat Gain (Minus)	0.4
Total	1050.3×10^6

TABLE VII. Estimated and Actual Heat Loss By Month

	Heat Loss, BTU $\times 10^6$		
Month	Estimated By Program	Actual As Recorded	Estimated as % of Actual
End January 1974	111.51	109.96	98.6%
February 1974	470.66	461.87	101.9%
March 1974	382.26	457.91	83.5%
1st Half April 1974	85.86	221.56	38.8%
Total	1,050.29	1,251.30	83.9%

daytime when construction was in progress. Therefore, although the program assumes that the building's various heat flow characteristics remained constant over the period analyzed, in truth, these characteristics were changed during late March and early April. Thus, the program tends to underestimate the actual heat required, if a large amount of this heat is being lost to the outside.

In summary, then, based on a comparison of estimated and actual heat losses, it appears that the program does a good job of estimating such losses when conditions at the project are as represented by program input.

Another approach to the matter of program validity would be to compare the indicated air changes per hour with those that normally would be expected. Unfortunately, the author knows of no studies of air changes per hour of buildings under construction! For buildings whose construction has been completed and which are in operation, Jennings (5) indicates "For almost any type of room or space, a volume of air per hour equivalent to one-half to three times the volume of the room or space enters by infiltration and an equivalent volume leaves." Typical values give one and one-half changes of air per hour for a room with two sides exposed, one to three changes per hour for stores and one to two changes for living rooms.

To obtain an estimate for total air infiltration per hour, one must sum the values given by the program as "crack infiltration products," and divide the result by 0.018. Then, since it is assumed that one-half of this total enters the building and one-half leaves it, one should divide the result by two to determine that amount of air which must be heated to the inside air temperature each hour.

For the project under study, the sum is developed as follows:

Wall No. 3 windows	1838.3
Wall No. 3 doors	450.0
Wall No. 4 windows	1660.5
Wall No. 4 doors	702.0
Roof enclosures	3669.0
Total	8309.8

Dividing this total by 0.018 and then by two, the result is 233,606 cubic feet of air entering per hour. The total volume of the space whose dimensions are 108.2 feet by 71.67 feet by 18 feet is 139,585 cubic feet. Thus, the indicated air changes per hour are

$$\frac{233,606}{139,585} = 1.67 \text{ air changes per hour}$$

Lacking any data with which to compare this result, one can only say that it seems to fall within the range expected, for a building which is under construction and has relatively few windows but some large enclosures and about half of whose walls are below grade.

A final approach to the comparison of results determined by the program with those which would be expected in actual practice will be to look at the percentage that the various types of indicated heat losses are of the total heat loss.

A study by Konzo, as reported in Canadian National Research Council Better Building Bulletin #2 (2), gives the percentage heat loss of various types of houses in the United States that were of wood frame construction with basements, were uninsulated and had no storm windows, storm doors or weatherstripping. Konzo's study obviously did not focus on concrete frame buildings under construction, some of whose

walls are below grade, but the comparison, nonetheless, may shed some light on how well the program is predicting actual total heat loss.

Table VIII lists heat losses of four categories: walls and ceilings, windows and doors, cracks around windows and doors, and floors, as broken down in the Konzo study. Heat loss predicted by the program for the Laboratory Building Addition project is given, both in BTU's and in percentage of the total BTU loss. In addition, the percentages developed from the Konzo study are listed in Table VIII. Since the Konzo study was based on uninsulated houses, the percentage losses through walls and ceilings compared to windows and doors in his study would be considerably higher than modern day houses. For the laboratory addition project, the comparison of walls and ceilings losses to windows and doors losses shows that losses from walls and ceilings are predicted to be about six times those from windows and doors. An explanation is that the roof area of the laboratory addition first floor was a large, uninsulated expanse and the walls contained relatively few windows and doors, including none on the two portions of wall that were below grade.

Comparing the predicted "cracks around windows and doors" percentage with that from the Konzo report one notes that the predicted percentage is considerably higher, as would be expected with a building under construction. Finally, it is noted that the floor loss percentage is essentially the same as that developed in the Konzo report. Thus although the buildings compared are strikingly dissimilar, the results of the comparison discussed above seem to indicate that the program is developing reasonable results.

TABLE VIII. Percentage Heat Loss of Various Types

Predicted By Program

Type of Heat Loss	BTU's x 10^6	% of Total	% Given in Konzo Report
Walls and Ceilings	523.3	49.8%	43%
Windows and Doors	90.7	8.6	30%
Cracks around Windows and Doors	409.1	39.0	25%
Floors	27.2	2.6	2%
	1050.3	100.0%	100%

The results of the discussion in this section tend to indicate that the approach taken by this program can be expected to give reasonably valid results, results that generally will be well within the estimating accuracy employed in building construction estimating.

CONCLUSIONS

The process of construction is a year-round activity, even in the coldest of regions. As the literature search portion of this report has revealed, contractors have been building things in the winter for a long time. The coldest temperature reported at an on-going construction project was -70°F, at a bridge over the Forty-Mile River in the Yukon Territory. The literature review found many other building, highway, dam, canal, and bridge projects that were constructed at temperatures that sometimes reached far below 0°F.

Another portion of this project asked contractors, who are currently doing business in Alaska, how cold it must be before they shut down various types of construction operations and what other factors are important in deciding to shut down in the winter. Interestingly, the lowest temperature given by any respondent was also -70°F, by a contractor who felt that machine and hand excavation and some types of electrical work can be carried out at this temperature. Other factors mentioned as important in a decision to suspend winter work included the following: wind, snow, lack of daylight, soil moisture, icing conditions, transportation cost, type of work, size of job, availability of personnel, effect on other phases of the project, union attitude and quality control. With rapid development of Alaska and other northern areas, construction during cold weather is assuming a more important role than in the past, and this trend is likely to continue for some time.

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ESTIMATING HEATING REQUIREMENTS FOR BUILDINGS UNDER CONSTRUCTIO--ETC(U)
FEB 77 F L BENNETT DACA89-75-C-0538

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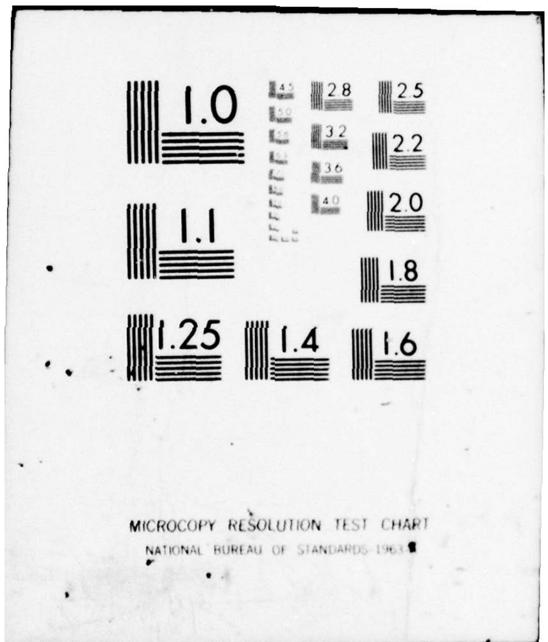
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

To assist construction contractors in estimating the costs of using temporary enclosures in buildings under construction and providing temporary heating for such buildings, this project's major effort has been to develop a heating and enclosures cost estimating computer program. The program is interactive, in the sense that the user communicates with the computer by means of a remote keyboard terminal in a "conversational" manner which allows different enclosures schemes to be evaluated by changing input data. Data on heat flow characteristics and cost of each exterior building element are supplied to the program, as are monthly climatic data. The program calculates total estimated heat loss for each month and for the total winter period and the costs of installing and maintaining enclosures and providing heating.

To determine how well the program estimates actual heat loss, it was used to calculate heat loss for the University of Alaska Laboratory Building Addition project, whose actual heat loss during construction had been documented during the 1973-74 winter. Results of this validation run indicate that the program does an acceptable job of estimating heat loss, well within the normal accuracy of building construction estimating. It is suggested that futher validation be carried out by applying the program to other building construction projects whose actual heat loss can be determined.

The study revealed the need for further study of the air loss characteristics around temporary windows and doors such as those in buildings under construction. An important data element for the HEATCOST computer program is the "crack infiltration factor" for each

window and door, which depends on the type of installation, its weatherstripping, etc. Although fairly accurate factors have been published for permanent-type doors and windows, no such data are available for such typical construction-project windows as those made of polyethylene sheeting and lumber framing. A modest research effort to determine such factors would be appropriate at this time.

APPENDIX I

Unedited Responses to Questionnaire Questions 2, 3 and 4

APPENDIX I. Unedited Responses
to Questionnaire Questions 2, 3 and 4.

2. "What determines the cutoff temperatures you have indicated?

Activities generally limited by the effect on people except where the physical characteristics of the material govern (concrete placement and curing, painting, etc.)

Handwork items are controlled by effect on people - wind chill factor. Equipment availability remains fairly good to -35°. Any drop below this destroys availability with -50° being impossible to work.

Elect. installation - human factor.

Effect on people and machinery.

Mostly productivity of people. Also product such as concrete and mortar may become very expensive to place because of plant protection, heating aggregates and water and jobsite protection during placing and curing.

All effect the working range - work can be performed depending on heating costs involved with protecting men, materials and equipment. Wind chill factor plays the largest variable on all of the above.

See above listing.

Metal failure on scrapers starts at approximately -35° (goose-necks). Dozers no problem till past -50°.

The above is based on temperature that can be worked efficiently - below that production drops way down and costs are prohibitive.

Considering usual compaction requirements of thin layers. Moisture content of materials and shrinkage considered. Building construction.

On equipment at that temperature it usually can't be started period, no matter what precautions. Work can be performed at these low temperatures - but you have no productivity to speak of.

+20° you can pull Romex, anything colder than that the insulation will crack. It's just a matter of how cold the man will work - could up to -30°.

Primarily soil and material norms. Some materials just cannot be worked without temporary heat and enclosures. Effect on people and machinery can be overcome but is expensive.

Can be performed at lower temperatures but effect on machinery offsets ability to work.

-30° is cutoff for both human performance and machine performance. About +20° is the cutoff for economical performance.

Motor and water freezing.

Hard to keep machines operational below 0° - hard to work dirt below 25° - hard to work people outside below 0°.

Soil, cut off without thawing, other draft with weather effecting, materials.

Freezing of materials.

Hydraulic machinery.

Excavation - soil conditions; painting, masonry, roofing, concrete - *effect on material*; carpentry, electrical, plumbing - effect on personnel.

A combination of all factors.

Temperatures below the 10 above - asphalt does not penetrate efficiently into the layers of felt. Shorter work hours and less production.

Not as good performing work when cold, not too much trouble with equipment, when serviced right, soil conditions are OK except for underground work, in that case we put in temporary until the ground thaws.

Effect on people, machinery.

Machine work - below -35° there is a severe "brittleness" effect on hoses, seals, etc. Very high machinery maintenance, surveying and other work with exposed personnel - effect on people.

Effect on people.

How much money is available. Alyeska has demonstrated that anything is possible. Most activities continued thru winter this year at greatly increased cost.

With adequately protected operator on machine, damage to machine components determines "cutoff" for work where men are exposed, loss of efficiency.

3. "What other factors besides temperature are important in a decision to suspend work in the winter?"

Urgency of the work and the money available to complete the job in spite of the cold temperature.

The effect of wind chill factor definitely controls the work. A wind chill factor of -40° to -50° or colder eliminates all hand work. Machinery can continue to operate, however, with -60° to -70° chill.

None.

Wind (chill factor). Snow, daylight (cost and safety of working under lights). Cost of transporation of supplies under adverse weather conditions, individual and machine productivity.

Chill factor, type of work involved, ie mass concrete vs thin wall, etc. Size of job, is money value involved for winter work a large % or small % of overall project.

Cost is high, efficiency is low, quality is reduced in the winter.

We must work two shifts or equipment cools out - moisture content of soil is also a factor - with proper lighting we have been able to sustain adequate grade.

We have done steel erection at 40 below with no wind - but that is about the maximum. Wind is to be considered regardless of temperature.

Logistics or material available - temporary heat available and costs involved - availability of good workers at that time of year, etc.

Also consider company situation - ie. is equipment needed elsewhere? Availability of personnel, consequential effect on other phases of work, chill factor, precipitation, geographic location.

Wind factor.

Cost, wind and precipitation, board and room conditions, work shift required.

Physical activity of individuals, haul lengths as far as concrete placement is concerned, proper preventative maintenance program, visibility, timing and goal of project.

Excessive snow (more than 3-4 inches), icing conditions, long darkness also affect road construction or site development (any outside work).

If a cover of visqueen or other suitable material is provided, work could go on all winter.

Chill factor due to wind, snow, sleet, ice fog create stoppages.

Snow covering material, time lost in men getting to work, sickness.

Lack of production.

We attempt to construct as much as possible indoors (prefab building modules, etc.) so we can do many things at lower temperatures. At this time our toughest hurdle is the effect of cold temperatures on heavy machinery and we feel -30 is the limit.

Lack of daylight - material storage - higher labor cost to prepare body for work.

Temperature has the dominant effect on other factors - production for the money spent is my chief concern.

Snow, frost.

Our work consists of inside wiring, mostly except for putting the power service in. The weather never stops us, you cannot get help in the winter months, the electricians don't want to quit drawing their welfare checks, unless you promise them steady work. That is one big problem. Another one is they are pricing themselves out of work $14.35/hr + 2.60 benefits.

Money to spend coupled with need is the real criteria - in other words, economics. There is no temperature cutoff unless coupled with costs. It just costs more money at lower temperatures. The impossible just costs more.

Cost to run equipment.

Survey - deep, soft snow and limited amount of daylight.

Efficiency.

Money, quality control, union attitude.

Trade-offs between loss of efficiency and higher costs against completion (less financing cost, etc.) and spread of fixed costs over more hours worked per year.

4. "Other comments?"

Higher winds cause white-outs or ground blizzards that make work on hauling or grading impossible.

Construction should be programmed to do outside tasks in the summer and interior work in winter.

With the heat of machines and visqueen and heaters, mechanics and operators are able to perform satisfactory work.

There are many considerations which affect the decision to undertake an operation. For example, heavy excavation in the fall tends to extend into colder temperatures than that same operation might be undertaken in the spring, because in the fall the ground is not frozen so deeply as it is in the spring. There may be six inches of frost at 20°F below in the fall (no problem for a ripper) and six feet of frozen ground when that temperature occurs in the spring. Conversely, ironworkers work better at 30°F below in the spring than in the fall, a function of psychology and daylight.

Roofing tends to be done deeper into the fall cold than might be considered practical in the spring because of need (the effect on other work). Also some operations, ie. masonry, are "easy" to provide temperature control for; thus the cost is not severely adversely affected by temporary enclosure. Obviously, it cannot be done below freezing. Similarly concrete forming is easy well beyond freezing whereas the concrete must be poured against unfrozen (and/or insulated) surfaces. Therefore, my temperatures are those at which no extended considerations are involved or at which the state of the art is so well founded that the considerations cannot be regarded as extraordinary.

New methods being devised for work on the Alaska Pipeline should be of great interest. We are doing things now that seemed impossible 10 years ago.

Many of the activities indicated can be performed at lower temperatures than those shown - efficiency of personnel and equipment and job requirements may require working at lower temperatures which will undoubtedly have an adverse effect on personnel, equipment and production.

Wind and freezing weather are very difficult to work with.

Importance of completion sometimes negates hardship in which case work can be accomplished at great expense regardless.

Men do not work as efficiently when they are not comfortable, much time is spent thawing equipment, warming up trucks and extra costs would be necessary for lost time.

Many activities better done in winter with frozen ground, streams, etc. Soils investigation with surface borne drill rigs an excellent example.

We placed 150 c.y. concrete at airport for Mukluk in January at -30°. Even Fairbanks Sand and Gravel is already making concrete this year. Lots of money around - we paid $75 for concrete and glad to get it.

Every situation is different - as reflected by unit bid price variations, area work load, etc. No hard and fast rules have been revealed to me, ever!

APPENDIX II

FORTRAN Program Listing

```
C
C     ESTIMATING HEATING REQUIREMENTS FOR BUILDINGS UNDER CONSTRUCTION IN COLD90
C       REGIONS -- AN INTERACTIVE COMPUTER APPROACH
C
C     PURCHASE ORDER NO. DACA89-75-0538
C
C     FOR U.S.ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
C         P.O.BOX 282
C         HANOVER, NEW HAMPSHIRE  03755
C
C     PROGRAM BY F.LAWRENCE BENNETT,P.E.
C                CONSULTING ENGINEER
C                P.O.BOX 80548
C                COLLEGE,ALASKA   99701
C
C     THIS PROGRAM ESTIMATES 1) HEATING COSTS FOR BUILDINGS UNDER CONSTRUCTION,0
C                            2) LABOR AND MATERIAL COSTS TO INSTALL TEMPORARY240
C                               ENCLOSURES INITIALLY, AND
C                            3) COST OF MAINTAINING THE ENCLOSURES.
C
C
C     DEFINITION OF VARIABLES --
C
C         ANS [ ANSWER TO \YES\ OR \NO\ QUESTION
C         ANSNO [ \NO\
C         AREANE [ NET AREA OF ONE WALL
C         BG(I) [ 1 IF WALL I IS BELOW GRADE. [ 0 OTHERWISE
C         COSMNT [ TOTAL ENCLOSURES MAINTENANCE COST FOR ONE MONTH
C         CRINW [ WINDOW CRACK INFILTRATION/HR FOR ONE WALL
C         CRIND [ DOOR CRACK INFILTRATION/HR FOR ONE WALL
C         CRINRE [ ROOF ENCLOSURES CRACK INFILTRATION
C         DA(J) [ TYPE J DOOR AREA
C         DAREA [ AREA OF ALL DOORS IN ONE WALL
C         DATAU [ A*TAU FOR DOORS IN ONE WALL
C         DAYS(K) [ DAYS IN KTH MONTH
C         DBTU [ BTUS LOST THROUGH DOORS FOR ONE MONTH
C         DCL [ DOOR LABOR COST FOR ONE WALL
C         DCM [ DOOR MATERIAL COST FOR ONE WALL
C         DCOSL(I,J) [ LABOR COST/SF FOR JTH DOOR TYPE IN ITH WALL, IF TEMPORARY
C         DCOSM(I,J) [ MATL COST/SF FOR JTH DOOR TYPE IN ITH WALL, IF TEMPORARYO
C         DCRBTU [ BTUS LOST DUE TO DOOR CRACKS FOR ONE MONTH
C         DH(I,J) [ HEIGHT OF JTH DOOR TYPE IN ITH WALL, INCHES
C         DIN(I,J) [ INFILTRATION FACTOR OF JTH DOOR TYPE IN ITH WALL,
C                                                CF/HR/FT OF CRACK
C         DNUM(I,J) [ NUMBER OF J TYPE DOORS IN ITH WALL
C         DPERIM [ PERIMETER OF ALL DOORS IN ONE WALL
C         DP(J) [ TYPE J DOOR PERIMETER
C         DTAU(I,J) [ SOLAR RADIATION TRANSMISSION FACTOR FOR JTH DOOR
C                                                              IN ITH WALL
C         DU(I,J) [ U FACTOR OF JTH DOOR TYPE IN ITH WALL, BTU/HR.SQ FT.DEG F570
C         DW(I,J) [ WIDTH OF JTH DOOR TYPE IN ITH WALL, INCHES
C         ENCLCO    [ TOTAL INSTALLATION COST FOR ENCLOSURES (LABOR & MATERIALS)0
C         FBG [ 1. IF FLOOR U FACTOR IS BASED ON SOIL TEMPERATURE,
C               [ 0 IF BASED ON AIR TEMPERATURE
C         FBTU [ BTUS LOST THROUGH FLOOR FOR ONE MONTH
C         FU [ U FACTOR FOR FLOOR
C         FUA [ U*A PRODUCT FOR FLOOR
C         GAREA [ GROSS AREA OF ONE WALL
C         GAR [ GROSS AREA OF ROOF
C         GATAUE [ GRAND TOTAL A*TAU FOR WINDOWS AND DOORS FACING EAST OR WEST70
C         GATAUH [ GRAND TOTAL A*TAU FOR ROOF ENCLOSURES
C         GATAUS [ GRAND TOTAL A*TAU FOR WINDOWS AND DOORS FACING SOUTH
C         HEATYP(1) -- HEATYP(10)   [ TYPE OF TEMPORARY HEATING
C         HEATCO    [ HEATING COST PER 1000 BTUS
C         HRT [ HRS PER MONTH * TEMPERATURE DELTA
C         HTGCOS   [ TOTAL HEATING COST IN ONE MONTH
C         I [ COUNTER FOR WALL NUMBER (1-20)
C         IDENT(1)--IDENT(20) [ PROJECT IDENTIFICATION
C         IMON [ 1 IF THIS IS LAST MONTH, [ 0 OTHERWISE
C         J [ COUNTER FOR WINDOW OR DOOR TYPE (1-3)
C         K [ DESIGNATES END OF WALL DATA IF K [ 1.
C         MONAME(K,1)--MONAME(K,4) [ NAME OF KTH MONTH
C         MORE [ 1 IF THIS IS A REVISION PASS, 0 IF NOT
C         NPRINT [ PRINTER DATA SET REFERENCE NUMBER
C         NREAD [ READER DATA SET REFERENCE NUMBER
C         NUMMO [ NUMBER OF MONTHS
C         NUMWAL  [ TOTAL NUMBER OF WALLS IN ANALYSIS
C         OUTEMP(K) [ AVG OUTSIDE TEMPERATURE IN KTH MONTH
C         PCTMAI   [ MONTHLY MAINTENANCE PERCENTAGE FOR TEMPORARY ENCLOSURES0860
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C     PCTMO(K) [ MAINTENANCE PCT FOR KTH MONTH                          00000870
C     RBTU [ BTUS LOST THROUGH ROOF FOR ONE MONTH                       00000880
C     REA(J) [ AREA OF TYPE J ROOF ENCLOSURES                           00000890
C     REAREA [ TOTAL AREA OF ROOF TEMPORARY ENCLOSURES                  00000900
C     REBTU [ BTUS LOST THROUGH ROOF TEMPORARY ENCLOSURES FOR ONE MONTH00000910
C     RECL(J) [ LABOR COST FOR TYPE J ROOF TEMPORARY ENCLOSURE, $/SF00000920
C     RECM(J) [ MATERIAL COST FOR TYPE J ROOF TEMPORARY ENCLOSURE, $/SF00930
C     RECRBT  [ BTUS LOST DUE TO ROOF TEMP ENCLOSURES CRACKS IN ONE MONTH940
C     REIN(J) [ INFILTRATION FACTOR FOR TYPE J ROOF TEMPORARY ENCLOSURE00950
C     REL(J) [ LENGTH OF TYPE J ROOF TEMPORARY ENCLOSURE, INCHES        00000960
C     RENUM(J) [ NUMBER TYPE J TEMPORARY ENCLOSURES IN ROOF             00000970
C     REP(J) [ PERIMETER OF TYPE J ROOF ENCLOSURES                      00000980
C     REPERI  [ TOTAL PERIMETER OF ROOF TEMPORARY ENCLOSURES            00000990
C     RETAU(J) [ SOLAR RADIATION TRANSMISSION FACTOR FOR TYPE J ROOF00001000
C                                                    TEMPORARY ENCLOSURE0
C     REU(J) [ U FACTOR FOR TYPE J ROOF TEMPORARY ENCLOSURE             00001020
C     REW(J) [ WIDTH OF TYPE J ROOF TEMPORARY ENCLOSURE, INCHES         00001030
C     RL [ ROOF LENGTH, FEET                                            00001040
C     RNA [ NET AREA OF ROOF                                            00001050
C     RU [ ROOF U FACTOR                                                00001060
C     RW [ ROOF WIDTH, FEET                                             00001070
C     SOILTE(K)   [ AVG SOIL TEMPERATURE IN KTH MONTH                   00001080
C     SOLEW(K) [ SOLAR RADIATION (BTU/SF) FOR MONTH K FOR THIS LOCATION01090
C              ON VERTICAL EAST OR WEST FACING SURFACE                  00001100
C     SOLH(K) [ SOLAR RADIATION (BTU/SF) FOR MONTH K FOR THIS LOCATION001110
C                                      ON HORIZONTAL SURFACE            00001120
C     SOLS(K) [ SOLAR RADIATION (BTU/SF) FOR MONTH K FOR THIS LOCATION001130
C                                 FOR VERTICAL SOUTH FACING SURFACE01140
C     SOLHTG [ SOLAR HEAT GAIN IN ONE MONTH                             00001150
C     SUMBTU [ TOTAL OF ALL BTUS LOST IN ONE MONTH                      00001160
C     TCOST [ GRAND TOTAL OF ALL COSTS                                  00001170
C     TCRINW [ GRAND TOTAL CRACK INFILTRATION PRODUCTS FOR WINDOWS      00001180
C     TCRIND [ GRAND TOTAL CRACK INFILTRATION PRODUCTS FOR DOORS        00001190
C     TDBTU [ GRAND TOTAL BTUS LOST THROUGH DOORS                       00001200
C     TDCL [ GRAND TOTAL DOOR LABOR COST                                00001210
C     TDCM [ GRAND TOTAL DOOR MATERIAL COST                             00001220
C     TDCRBT  [ GRAND TOTAL BTUS LOST THROUGH DOOR CRACKS               00001230
C     TEMPIN [ AVERAGE INSIDE TEMPERATURE                               00001240
C     TFBTU [ GRAND TOTAL BTUS LOST THROUGH FLOOR                       00001250
C     THTGCO  [ GRAND TOTAL HEATING COSTS                               00001260
C     TINMO(K) [ AVG INSIDE TEMPERATURE IN KTH MONTH                    00001270
C     TMNTCO   [ GRAND TOTAL MAINTENANCE COSTS                          00001280
C     TRBTU [ GRAND TOTAL BTUS LOST THROUGH ROOF                        00001290
C     TRECL [ ROOF ENCLOSURES LABOR COST                                00001300
C     TRECM [ ROOF ENCLOSURES MATERIAL COST                             00001310
C     TREBTU [ GRAND TOTAL BTUS LOST THROUGH ROOF TEMPORARY ENCLOSURES001320
C     TRECRB   [ GRAND TOTAL BTUS LOST THROUGH ROOF TEMP ENCLOSURES CRACKS530
C     TSOLHT [ GRAND TOTAL SOLAR HEAT GAIN                              00001340
C     TSUMBT  [ GRAND TOTAL OF ALL BTUS LOST                            00001350
C     TUAWAL  [ GRAND TOTAL OF U*A PRODUCTS FOR ABOVE GRADE WALLS       00001360
C     TUAWIN [ GRAND TOTAL OF U*A PRODUCTS FOR WINDOWS                  00001370
C     TUAD [ GRAND TOTAL OF U*A PRODUCTS FOR DOORS                      00001380
C     TUABG [ TOTAL U*A PRODUCT FOR BELOW GRADE WALLS                   00001390
C     TWBTU [ GRAND TOTAL BTUS LOST THROUGH WALLS                       00001400
C     TWCL [ GRAND TOTAL WINDOW LABOR COST                              00001410
C     TWCM [ GRAND TOTAL WINDOW MATERIAL COST                           00001420
C     TWINBT  [ GRAND TOTAL BTUS LOST THROUGH WINDOWS                   00001430
C     TWNCRB    [ GRAND TOTAL BTUS LOST THROUGH WINDOW CRACKS           00001440
C     UAD [ DOOR U*A FOR ONE WALL                                       00001450
C     UARE [ ROOF ENCLOSURES U*A PRODUCT                                00001460
C     UAROOF [ U*A PRODUCT FOR ROOF                                     00001470
C     UAWIN [ WINDOW U*A FOR ONE WALL                                   00001480
C     WA(J) [ TYPE J WINDOW AREA                                        00001490
C     WAREA [ AREA OF ALL WINDOWS IN ONE WALL                           00001500
C     WBTU [ BTUS LOST THROUGH WALLS FOR ONE MONTH                      00001510
C     WCL [ WINDOW LABOR COST FOR ONE WALL                              00001520
C     WCM [ WINDOW MATERIAL COST FOR ONE WALL                           00001530
C     WH(I) [ HEIGHT OF ITH WALL, FEET                                  00001540
C     WINH(I,J) [ HEIGHT OF JTH WINDOW TYPE IN ITH WALL, INCHES         00001550
C     WINW(I,J) [ WIDTH OF JTH WINDOW TYPE IN ITH WALL, INCHES          00001560
C     WINU(I,J) [ U FACTOR OF JTH WINDOW TYPE IN ITH WALL,BTU/HR.SQ FT.DEG F
C     WININ(I,J) [ INFILTRATION FACTOR OF JTH WINDOW TYPE IN ITH WALL,001580
C                                                  CF/HR/FT OF CRACK590
C     WINNUM(I,J) [ NUMBER OF J TYPE WINDOWS IN ITH WALL                00001600
C     WINCSL(I,J)   [ LABOR COST/SF FOR JTH WINDOW TYPE IN ITH WALL, IF001610
C                                                          TEMPORARY1620
C     WINCSM(I,J)   [ MATERIAL COST/SF FOR JTH WINDOW TYPE IN ITH WALL, IF630
C                                                          TEMPORARY0
C     WINBTU [ BTUS LOST THROUGH WINDOWS FOR ONE MONTH                  00001650
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C         WINCRB    [ BTUS LOST DUE TO WINDOW CRACKS FOR ONE MONTH
C         WINTAU(I,J) [ SOLAR RADIATION TRANSMISSION FACTOR FOR JTH WINDOW TYPE
C                                                       IN ITH WALL
C         WNATAU [ A*TAU FOR WINDOWS IN ONE WALL
C         WOD(I) [ WALL ORIENTATION DESIGNATOR FOR WALL I       1. [ SOUTH
C                                                               2. [ EAST OR WEST
C                                                               3. [ NORTH
C         WPERIM [ PERIMETER OF ALL WINDOWS IN ONE WALL
C         WP(J) [ TYPE J WINDOW PERIMETER
C         WU(I) [ U FACTOR OF ITH WALL, BTU/HR.SQ FT.DEG F
C         WW(I) [ WIDTH OF ITH WALL, FEET
C
      DIMENSION IDENT(15),WH(20),WW(20),WU(20),WINH(20,3),WINW(20,3),
     &WINU(20,3),WININ(20,3),WINNUM(20,3),WINCSL(20,3),WINCSM(20,3),
     &DH(20,3),DW(20,3),DU(20,3),DIN(20,3),DNUM(20,3),DCOSL(20,3)
      DIMENSION DCOSM(20,3),WA(3),DA(3),WP(3),DP(3),RENUM(2),REL(2),
     &REW(2),REU(2),REIN(2),RECL(2),RECM(2),REA(2),REP(2),BG(20),
     &HEATYP(10), MONAME(12,4),DAYS(12),OUTEMP(12),SOILTE(12),
     &TINMO(12),PCTMO(12)
      DIMENSION WINTAU(20,3),DTAU(20,3),WOD(20),RETAU(2),SOLH(12),
     &SOLS(12),SOLEW(12)
C
      DATA ANSNO/\NO\/
C
      NREAD [ 5
      NPRINT [ 6
      MORE [ 0
      WRITE(NPRINT,500)
  500 FORMAT(\1\,T5,\HEATCOST -- A PROGRAM FOR ESTIMATING THE COST OF TE
     &MPORARY HEATING\,/,T8,\ AND ENCLOSURES DURING CONSTRUCTION\,//,
     &T5,\TYPE PROJECT IDENTIFICATION -- UP TO 60 CHARACTERS\)
C   INPUT PROJECT IDENTIFICATION
C
      READ(NREAD,10)IDENT
   10 FORMAT(15A4)
  730 WRITE(NPRINT,20)IDENT
   20 FORMAT(T10,15A4,//)
      DO 30 I[1,20
      IF(MORE.EQ.0)GO TO 810
      WRITE(NPRINT,800)I
  800 FORMAT(T5,\ARE THERE ANY WALL DATA REVISIONS FOR WALL \,I2)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 820
  810 WRITE(NPRINT,510)I
  510 FORMAT(T5,\TYPE WALL DATA FOR WALL \,I2,\ --HEIGHT IN FEET,WIDTH I
     &N FEET,U FACTOR,\, /,T8,
     &              \BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF AB
     &OVE GRADE)\,/,T8,\WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2
     &. IF EAST\,/,T8,
     &         \OR WEST FACING, 3. IF NORTH FACING).\)
C
C   INPUT WALL DATA -- HEIGHT, WIDTH, U FACTOR, BELOW GRADE DESIGNATOR,
C                              WALL ORIENTATION DESIGNATOR
C
      READ,              WH(I),WW(I),WU(I),BG(I),WOD(I)
C
C   INPUT WINDOW DATA FOR THIS WALL -- NUMBER, HEIGHT, WIDTH, U FACTOR,
C       INFILTRATION FACTOR, SOLAR RADIATION TRANSMISSION FACTOR, LABOR COST,
C         MATERIAL COST  (3 CARDS -- ONE FOR EACH WINDOW TYPE)
C
  820 DO 50 J[1,3
      IF(MORE.EQ.0)GO TO 830
      WRITE(NPRINT,840)J,I
  840 FORMAT(T5,\ARE THERE ANY REVISIONS TO WINDOW TYPE \,I1,\ DATA IN W
     &ALL \,I2)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 50
  830 WRITE(NPRINT,520)J
  520 FORMAT(T5,\TYPE WINDOW DATA FOR TYPE \,I1,\ WINDOWS FOR THIS WALL,
     & IF ANY --\,/,T8,
     &         \NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,\,/,
     &T8,\CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),\,/,T8,
     &                                                  \SOLAR RADIATI
     &ON TRANSMISSION RATIO(BETWEEN 0. AND 1.0),\,/,T8,\INSTALLATION LAB
     &OR COST/SF,MATERIAL COST/SF.\)
      READ,           WINNUM(I,J),WINH(I,J),WINW(I,J),WINU(I,J),WININ(I,J)
     &,WINTAU(I,J),WINCSL(I,J),WINCSM(I,J)
   50 CONTINUE
C
```

```
C   INPUT DOOR DATA FOR THIS WALL -- NUMBER, HEIGHT, WIDTH, U FACTOR,
C     INFILTRATION FACTOR, SOLAR RADIATION TRANSMISSION FACTOR, LABOR COST.
C     MATERIAL COST    (3 CARDS -- ONE FOR EACH DOOR TYPE)
C
      DO 70 J[1,3
      IF(MORE.EQ.0)GO TO 850
      WRITE(NPRINT,860)J,I
  860 FORMAT(T5,\ARE THERE ANY REVISIONS TO DOOR TYPE \,I1,\ DATA IN WAL
     6L \,I2)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 70
  850 WRITE(NPRINT,530)J
  530 FORMAT(T5,\TYPE DOOR DATA FOR TYPE \,I1,\ DOORS FOR THIS WALL, IF
     6 ANY.\,/,T8,\ SAME DATA AND ORDER AS FOR WINDOWS.\)
      READ,          DNUM(I,J),DH(I,J),DW(I,J),DU(I,J),DIN(I,J),DTAU(I,J)
     6,DCOSL(I,J),DCOSM(I,J)
   70 CONTINUE
      WRITE(NPRINT,540)I
  540 FORMAT(T5,\IS WALL \,I2,\ THE LAST WALL\)
      READ(NREAD,550)ANS
  550 FORMAT(A2)
      IF(ANS.NE.ANSNO)GO TO 80
   30 CONTINUE
   80 NUMWAL   [ I
C
C   FOR EACH WALL, FIND GROSS AREA, WINDOW AREA, DOOR AREA, NET AREA, U*A,
C     CRACK INFILTRATION AND COSTS
C
      TWCL [ 0.
      TWCM [ 0.
      TDCL [ 0.
      TDCM [ 0.
      TUAWAL   [ 0.
      TUAWIN [ 0.
      TUAD [ 0.
      TCRINW [ 0.
      TCRIND [ 0.
      TUABG [ 0.
      GATAUS [ 0.
      GATAUE [ 0.
      DO 90 I[1,NUMWAL
      WRITE(NPRINT,100)I
  100 FORMAT(T20,\WALL NUMBER \,I2)
      GAREA [  WH(I)*WW(I)
      WCL [ 0.
      WCM [ 0.
      DCL [ 0.
      DCM [ 0.
      UAWIN [  0.
      UAD [ 0.
      CRINW [  0.
      CRIND [  0.
      WAREA [  0.
      DAREA [  0.
      WPERIM [  0.
      DPERIM [  0.
      WNATAU [  0.
      DATAU [ 0.
      DO 110 J [  1,3
      WA(J)  [  WINNUM(I,J)*WINH(I,J)*WINW(I,J)/144.
      DA(J)  [  DNUM(I,J)*DH(I,J)*DW(I,J)/144.
      WP(J)  [  WINNUM(I,J)*2.*(WINH(I,J)^WINW(I,J))/12.
      DP(J)  [  DNUM(I,J)*2.*(DH(I,J)^DW(I,J))/12.
      WCL  [  WA(J)*WINCSL(I,J)   ^ WCL
      WCM  [  WA(J)*WINCSM(I,J)   ^ WCM
      DCL  [  DA(J)*DCOSL(I,J)  ^ DCL
      DCM  [  DA(J)*DCOSM(I,J)  ^ DCM
      UAWIN  [  UAWIN  ^  WA(J)*WINU(I,J)
      UAD  [  UAD  ^  DA(J)*DU(I,J)
      CRINW  [  CRINW  ^  WP(J)*WININ(I,J)*0.018
      CRIND  [  CRIND  ^  DP(J)*DIN(I,J)*0.018
      WAREA  [  WAREA  ^  WA(J)
      DAREA  [  DAREA  ^  DA(J)
      WPERIM  [  WPERIM  ^  WP(J)
      DPERIM  [  DPERIM  ^  DP(J)
      WNATAU  [  WNATAU  ^  WA(J)*WINTAU(I,J)*(1.-BG(I))
      DATAU[  DATAU  ^  DA(J)*DTAU(I,J)*(1.-BG(I))
  110 CONTINUE
      AREANE   [  GAREA  -  WAREA  -  DAREA
```

```
      UAWALL [ AREANE *WU(I)
      WRITE(NPRINT,120)GAREA,WAREA,DAREA,AREANE ,WCL,WCM,DCL,DCM,UAWALL,
&UAWIN,UAD,CRINW,CRIND
  120 FORMAT(T7,\GROSS AREA [ \,F7.1,\ SF  ,WINDOW AREA [ \,F7.1,\ SF\,
&/,T8,                                                           \
&DOOR AREA [ \,F7.1,\ SF   NET AREA [ \,F7.1,\ SF\,/,T9,\WINDOW COS
&TS--LABOR [ $\,F7.2,\   MATERIALS [ $\,F7.2/T10, \DOOR COSTS--LABO
&R [ $\,F7.2,\   MATERIALS [ $\,F7.2,/,T11,\U*A PRODUCTS--WALL [ \,
&F6.1,\  WINDOWS [ \,F6.1,\  DOORS [\,F6.1/T12,\CRACK INFILTRATION
& PRODUCTS--WINDOWS [ \,F6.1,\  DOORS [\,F6.1)
      WRITE(NPRINT,122)WNATAU,DATAU
  122 FORMAT(T13,\SOLAR RADIATION PRODUCTS--WINDOWS [ \,F6.1,\  DOORS [
&\,F6.1,//)
      IF(BG(I).EQ.1.)GO TO 125
      TUAWAL  [ TUAWAL  ^ UAWALL
      TUAWIN [ TUAWIN ^ UAWIN
      TUAD [ TUAD ^ UAD
      TCRINW [ TCRINW ^ CRINW
      TCRIND [ TCRIND ^ CRIND
      TWCL [ TWCL ^ WCL
      TWCM [ TWCM ^ WCM
      TDCL [ TDCL ^ DCL
      TDCM [ TDCM ^ DCM
      IF(WOD(I)-2.)124,126,90
  124 GATAUS [ GATAUS ^ WNATAU ^ DATAU
      GO TO 90
  126 GATAUE [ GATAUE ^ WNATAU ^ DATAU
      GO TO 90
  125 TUABG [ TUABG ^ UAWALL
   90 CONTINUE
      IF(MORE.EQ.0)GO TO 870
      WRITE(NPRINT,880)
  880 FORMAT(T5,\ARE THERE ANY REVISIONS TO ROOF DATA\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 890
  870 WRITE(NPRINT,560)
  560 FORMAT(T5,\TYPE ROOF LENGTH IN FEET, WIDTH IN FEET AND U FACTOR.\)
C
C  READ ROOF LENGTH, WIDTH, UFACTOR, TEMPORARY ENCLOSURE DATA, IF ANY  (NUMBER,0
C       LENGTH, WIDTH, U FACTOR, INFILTRATION FACTOR, SOLAR RADIATION
C     TRANSMISSION FACTOR, LABOR COST, MATERIAL COST) FOR 2 TYPES (ON 3 CARDS)0
C
      READ,          RL,PW,RU
  890 DO 131 J[1,2
      IF(MORE.EQ.0)GO TO 900
      WRITE(NPRINT,910)J
  910 FORMAT(T5,\ARE THERE ANY REVISIONS TO ROOF ENCLOSURE TYPE \,I1,\ D
&ATA\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 131
  900 WRITE(NPRINT,570)J
  570 FORMAT(T5,\TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE \,I1,\ ENCL
&OSURES, IF ANY--\ ,/,T8,\NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U
& FACTOR,\,/,T8,
&      \CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),\,/,T8,\S
&OLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),\,/,T8,
&                                                  \INSTALLATION
& LABOR COST/SF,MATERIAL COST/SF,\)
      READ,         RENUM(J),REL(J),REW(J),REU(J),REIN(J),RETAU(J),
&RECL(J),RECM(J)
  131 CONTINUE
C
C  ROOF CALCULATIONS
C
      REPERI  [ 0.
      REAREA [ 0.
      CRINRE [ 0.
      UARE [ 0.
      TRECL [ 0.
      TRECM [ 0.
      GATAUH [ 0.
      GAR [ RL*RW
      DO 140 J[1,2
      REA(J) [ RENUM(J)*REL(J)*REW(J)/144.
      REP(J) [ RENUM(J)*2.*(REL(J)^REW(J))/12.
      UARE [ UARE ^ REU(J)*REA(J)
      CRINRE [ CRINRE ^ REP(J)*REIN(J)*0.018
      REPERI [ REPERI  ^ REP(J)
      REAREA [ REAREA ^ REA(J)
```

```
      TRECL [ TRECL ^ REA(J)*RECL(J)
      TRECM [ TRECM ^ REA(J)*RECM(J)
      GATAUH [ GATAUH ^ REA(J)*RETAU(J)
  140 CONTINUE
      RNA [ GAR - REAREA
      UAROOF [ RNA*RU
C
C
      WRITE (NPRINT,150)GAR,REAREA,RNA,TRECL,TRECM,UAROOF,UARE,CRINRE,
&GATAUH
  150 FORMAT(///,T7,\GROSS ROOF AREA [ \,F7.1,\ SF   TEMPORARY ENCLOSURE
&S AREA(ROOF) [ \,/,T8,
&                F7.1,\ SF   NET ROOF AREA [ \,F7.1,\ SF\,/,T9,\RO
&OF TEMPORARY ENCLOSURES COSTS--LABOR [ $\,F7.2,\   MATERIALS\,
&/,T10,\[ $\,
&F7.2,/,T11,\U*A PRODUCTS--ROOF [ \,F6.1,\  TEMPORARY ENCLOSURES[ \
&,F6.1,/,T12,
&        \CRACK INFILTRATION PRODUCT [ \,F6.1,/,T13,\SOLAR RADIATION
& PRODUCT [ \,F7.1)
C
C  READ FLOOR DATA -- U FACTOR, BELOW GRADE DESIGNATOR
C
      IF(MORE.EQ.0)GO TO 920
      WRITE(NPRINT,930)
  930 FORMAT(T5,\ARE THERE ANY REVISIONS TO FLOOR DATA\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 940
  920 WRITE(NPRINT,580)
  580 FORMAT(T5,\TYPE FLOOR U FACTOR & FACTOR BASIS DESIGNATOR(1.[U BASE
&D ON SOIL\,/,T8,
&        \TEMPERATURE, 0.[U BASED ON OUTSIDE AIR TEMPERATURE)\)
      READ,             FU,FBG
  940 FUA [ GAR*FU
C
C
      WRITE(NPRINT,170)GAR,FUA
  170 FORMAT(///,T7,\FLOOR AREA [ \,F7.1,\ SF   U*A PRODUCT FOR FLOOR [
&\,F7.1,///)
C
C  READ DATA ON HEATING METHOD, COST/1000 BTUS, AVG INSIDE TEMP, MONTHLY
C      MAINTENANCE COST (PCT OF TOTAL INSTALLATION COST)
C
      IF(MORE.EQ.0)GO TO 950
      WRITE(NPRINT,960)
  960 FORMAT(T5,\ARE THERE REVISIONS TO HEATING METHOD DESCRIPTION\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 970
  950 WRITE(NPRINT,590)
  590 FORMAT(T5,\TYPE DESCRIPTION OF HEATING METHOD--UP TO 40 CHARACTERS
&\)
      READ(NREAD,600)HEATYP
  600 FORMAT(10A4)
  970 IF(MORE.EQ.0)GO TO 980
      WRITE(NPRINT,990)
  990 FORMAT(T5,\ARE THERE ANY REVISIONS TO HEATING COST, INSIDE TEMPERA
&TURE\,/,T8,\OR MAINTENANCE COST\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 1000
  980 WRITE(NPRINT,610)
  610 FORMAT(T5,\TYPE HEATING COST/1000 BTUS,AVERAGE INSIDE TEMPERATURE,
&AND MONTHLY\,/,T8,
&        \COST OF MAINTAINING ENCLOSURES(AS PCT OF FIRST COST)\)
      READ,             HEATCO,TEMPIN,PCTMAI
C
C
 1000 WRITE(NPRINT,190)HEATYP ,HEATCO   ,TEMPIN,PCTMAI
  190 FORMAT(T5,\TEMPORARY HEATING WILL BE \,10A4/T10,\ AT A COST OF $\,
&F6.5,\ PER 1000 BTUS\,/,T15,\THE ASSUMED AVERAGE INSIDE TEMPERATUR
&E IS \,F4.1,\ DEG F\,/,T20,\THE ASSUMED COST OF MAINTAINING TEMPOR
&ARY ENCLOSURES\,/,T25,
&                \IS \,F4.1,\ PERCENT OF FIRST COST PER MONTH.\)
C
C  READ DATA ON EACH MONTH (NAME, NUMBER OF DAYS, AVG OUTSIDE TEMPERATURE,
C      AVG SOIL TEMPERATURE, AVG INSIDE TEMPERATURE (IF DIFFERENT FROM ORIGINAL
C      INPUT), MAINTENANCE COST PERCENT (IF DIFFERENT FROM ORIGINAL INPUT), AND
C      LAST MONTH INDICATOR).
C  PERFORM CALCULATIONS AND PRINT RESULTS.
C
      TWBTU [ 0.
```

```
      TWINBT  [ 0.
      TDBTU [ 0.
      TFBTU [ 0.
      TRBTU [ 0.
      TREBTU [ 0.
      TWNCRB   [ 0.
      TDCRBT  [ 0.
      TRECRB   [ 0.
      THTGCO   [ 0.
      TMNTCO   [ 0.
      TSOLHT [ 0.
      ENCLCO   [ TWCL ^ TWCM ^ TDCM ^ TRECL ^ TRECM ^ TDCL
      DO 200 K[1,12
      IF(MORE.EQ.0)GO TO 1010
      WRITE(NPRINT,1020)K
 1020 FORMAT(T5,\ARE THERE ANY REVISIONS TO MONTH \,I2,\ DATA\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 1030
 1010 WRITE(NPRINT,630)K
  630 FORMAT(T5,\TYPE NAME OF MONTH \,I2)
      READ(NREAD,210)(MONAME(K,I),I[1,4)
  210 FORMAT(4A4)
      WRITE(NPRINT,1015)
 1015 FORMAT(T5,\TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATUR
     &E,\,/,T8,
     &\AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE\,/,T8,
     &                                                  \(IF DIFFERENT
     & FROM ORIGINAL INPUT),\,/,T8,\SOLAR RADIATION(BTU/SF)FOR THE MONTH
     & ON HORIZONTAL,VERTICAL\,/,T8,
     &                    \SOUTH-FACING AND VERTICAL EAST- OR WEST-FAC
     &ING SURFACES,\,/,T8,\MAINTENANCE COST PERCENT(IF DIFFERENT FROM OR
     &IGINAL INPUT),\)
      READ,DAYS(K),OUTEMP(K),SOILTE(K),TINMO(K),SOLH(K),SOLS(K),
     &SOLEW(K),PCTMO(K)
      IF(TINMO(K).EQ.0.)TINMO(K) [ TEMPIN
      IF(PCTMO(K).EQ.0.)PCTMO(K) [ PCTMAI
 1030 HRT [ (TINMO(K) - OUTEMP(K))*24.*DAYS(K)
      WBTU [ HRT*TUAWAL ^ (TINMO(K) - SOILTE(K)   )*TUABG*24.*DAYS(K)
      TWBTU [ TWBTU ^ WBTU
      WINBTU [ HRT * TUAWIN
      TWINBT  [ TWINBT  ^ WINBTU
      DBTU [ HRT * TUAD
      TDBTU [ TDBTU ^ DBTU
      FBTU [ FUA*((TINMO(K)-SOILTE   (K))*FBG ^ (TINMO(K)-OUTEMP(K))*(1.-
     &FBG))*24.*DAYS(K)
      TFBTU [ TFBTU ^ FBTU
      RBTU [ HRT*UAROOF
      TRBTU [ TRBTU ^ RBTU
      REBTU [ HRT * UARE
      TREBTU [ TREBTU ^ REBTU
      WINCRB   [ HRT*TCRINW/2.
      TWNCRB   [ TWNCRB   ^ WINCRB
      DCRBTU [ HRT*TCRIND/2.
      TDCRBT   [ TDCRBT   ^ DCRBTU
      RECRBT   [ HRT*CRINRE/2.
      TRECRB    [ TRECRB    ^ RECRBT
      SOLHTG [ SOLH(K)*GATAUH^SOLS(K)*GATAUS ^ SOLEW(K)*GATAUE
      TSOLHT [ TSOLHT ^ SOLHTG
C
C
      SUMBTU [ WBTU ^ WINBTU ^ DBTU ^ FBTU ^ RBTU ^ REBTU ^ WINCRB   ^
     &DCRBTU ^ RECRBT - SOLHTG
      HTGCOS   [ SUMBTU * HEATCO  /1000.
      COSMNT   [ (PCTMO(K)/100.)*ENCLCO
      THTGCO   [ THTGCO    ^ HTGCOS
      TMNTCO   [ TMNTCO    ^ COSMNT
C
      WRITE(NPRINT,218)
  218 FORMAT(//)
      WRITE(NPRINT,220)(MONAME(K,I),I[1,4),DAYS(K),OUTEMP(K),SOILTE(K),
     &TINMO(K),SUMBTU,HTGCOS ,COSMNT ,PCTMO(K)
  220 FORMAT(T5,\FOR \,4A4,\, WHICH HAS \,F3.0,\ DAYS, AND AVERAGE TEMPE
     &RATURES\,/,T8,
     &      \OF \,F5.1,\ (OUTSIDE),\,/,T11,F5.1,\ (SOIL), AND\,/,T11,F5
     &.1,\ (INSIDE),\,/,T10,\THE TOTAL HEAT LOSS IS \,F10.0,\ BTUS,\,/,
     &T10,                                                   \THE
     & ESTIMATED HEATING COST IS $\,F7.2,/,T10,\AND THE ESTIMATED ENCLOSU
     &RES MAINTENANCE COST IS $\,F7.2,/,T10,
     &                              \(BASED ON \,F5.2,\ PCT OF INITI
```

```
&AL INSTALLATION COST)\)
      WRITE(NPRINT,640)K
  640 FORMAT(T5,\IS MONTH \,I2,\ THE LAST MONTH\)
      READ(NREAD,550)ANS
      IF(ANS.NE.ANSNO)GO TO 230
  200 CONTINUE
      WRITE(NPRINT,240)
  240 FORMAT(T25,\***PROGRAM HANDLES ONLY 12 MONTHS--NOTE POSSIBLE ERROR
&***\)
 230  TCOST [ ENCLCO    - THTGCO    - TMNTCO
      NUMMO [ K
      TSUMBT  [ TWBTU - TWINBT    - TDBTU - TFBTU - TRBTU - TREBTU -
&TWNCRB     - TDCRBT    - TRECRB - TSOLHT
      WRITE(NPRINT,250)TWBTU,TWINBT ,TDBTU,TFBTU,TRBTU,TREBTU,TWNCRB  ,
&TDCRBT,TRECRB,TSOLHT,TSUMBT,ENCLCO,THTGCO,TMNTCO,TCOST
  250 FORMAT(\1\,T10,\TOTAL BTUS LOST ARE AS FOLLOWS--\,/,T15,\WALLS\,
&T40,F11.0,/,T15,\WINDOWS\,T40,F11.0,/,T15,\DOORS\,T40,F11.0,/,T15,
&\FLOOR\,T40,F11.0,/,T15,\ROOF\,T40,F11.0,/,T15,\ROOF ENCLOSURES\,
&T40,F11.0,/,T15,\WINDOW CRACKS\,T40,F11.0,/,T15,\DOOR CRACKS\,T40,
&F11.0,/,T15,\ROOF ENCLOSURES CRACKS\,T40,F11.0,
&/,T15,\SOLAR HEAT GAIN (MINUS)\,T40,F11.0,
&                                                //,T20,\TOTAL\,T45,
&F12.0,///,T10,\TOTAL ESTIMATED COSTS ARE AS FOLLOWS--\,/,T20,\TEMP
&ORARY ENCLOSURES INSTALLATION\,T60,\$\,F8.2,/,T20,\HEATING\,T60,\$
&\,F8.2,/,T20,\TEMPORARY ENCLOSURES MAINTENANCE\,T60,\$\,F8.2,//,
&T25,\TOTAL\,T62,\$\,F8.2,/,\1\)
C
C
      WRITE(NPRINT,700)
  700 FORMAT(T5,\DO YOU WISH TO REVISE SOME INPUT DATA\)
      READ(NREAD,550)ANS
      IF(ANS.EQ.ANSNO)GO TO 710
      MORE [ 1
      GO TO 730
  710 WRITE(NPRINT,720)
  720 FORMAT(T5,\VERY WELL. THE ANALYSIS TERMINATES HERE.    **\)
C
C
      STOP
      END
```

APPENDIX III

Keyboard Listing for Validation Program Run

```
   HEATCOST -- A PROGRAM FOR ESTIMATING THE COST OF TEMPORARY HEATING
      AND ENCLOSURES DURING CONSTRUCTION

   TYPE PROJECT IDENTIFICATION -- UP TO 60 CHARACTERS
=LABORATORY BUILDING ADDITION  UNIV OF ALASKA  VALIDATION DATA
       LABORATORY BUILDING ADDITION  UNIV OF ALASKA  VALIDATION DAT

   TYPE WALL DATA FOR WALL  1 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
      BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
      WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST*
      OR WEST FACING, 3. IF NORTH FACING).
=18,134.91,.061,1,1
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  1 THE LAST WALL
=NO
   TYPE WALL DATA FOR WALL  2 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
      BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
      WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
      OR WEST FACING, 3. IF NORTH FACING).
=18,30.67,.061,1,2
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
```

```
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  2 THE LAST WALL
=NO
   TYPE WALL DATA FOR WALL  3 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
      BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
      WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING;2. IF EAST
      OR WEST FACING, 3. IF NORTH FACING).
=18,41,.063,,2
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=3,75,48,.93,750,.85,.2278,.0325
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,216,120,.93,1000,.85,.2278,.0325
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=1,84,36,.93,1500,.85,.2278,.0375
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
       SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  3 THE LAST WALL
=NO
```

```
   TYPE WALL DATA FOR WALL  4 --HEIGHT IN FEET,WIDTH IN FEET,U FACTOR,
      BELOW GRADE DESIGNATOR(1. IF BELOW GRADE, 0. IF ABOVE GRADE)
      WALL ORIENTATION DESIGNATOR(1. IF SOUTH FACING,2. IF EAST
      OR WEST FACING, 3. IF NORTH FACING).
=18,84,.061,,3
   TYPE WINDOW DATA FOR TYPE 1 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=6,75,48,.93,750..85,,2278,.0375
 6,75,48,.93,750..85,,2278,.0375

FILE CODE 41 ILLEGAL CHAR; CORRECTION =



,.85,.2278,.0375
   TYPE WINDOW DATA FOR TYPE 2 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE WINDOW DATA FOR TYPE 3 WINDOWS FOR THIS WALL, IF ANY --
      NUMBER, HEIGHT IN INCHES,WIDTH IN INCHES, U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 1 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=1,.084,72,.93,1500,.85,.2278,.0375
   TYPE DOOR DATA FOR TYPE 2 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   TYPE DOOR DATA FOR TYPE 3 DOORS FOR THIS WALL, IF ANY.
      SAME DATA AND ORDER AS FOR WINDOWS.
=,,,,,,,
   IS WALL  4 THE LAST WALL
=YES
                 WALL NUMBER  1
     GROSS AREA =  2428.4 SF   ,WINDOW AREA =      0.  SF
      DOOR AREA =      0.  SF    NET AREA =  2428.4 SF
       WINDOW COSTS--LABOR = $    0.       MATERIALS = $    0.
        DOOR COSTS--LABOR = $    0.       MATERIALS = $    0.
         U*A PRODUCTS--WALL =  148.1  WINDOWS =      0.    DOORS =    0.
          CRACK INFILTRATION PRODUCTS--WINDOWS =      0.    DOORS =    0.
           SOLAR RADIATION PRODUCTS--WINDOWS =     0.    DOORS =    0.
```

```
              WALL NUMBER  2
     GROSS AREA =    552.1 SF  ,WINDOW AREA =       0.  SF
      DOOR AREA =       0.  SF    NET AREA =    552.1 SF
       WINDOW COSTS--LABOR = $  0.     MATERIALS = $  0.
        DOOR COSTS--LABOR = $    0.    MATERIALS = $  0.
         U*A PRODUCTS--WALL =    33.7  WINDOWS =     0.    DOORS =     0.
          CRACK INFILTRATION PRODUCTS--WINDOWS =     0.    DOORS =     0.
           SOLAR RADIATION PRODUCTS--WINDOWS =     0.    DOORS =     0.

              WALL NUMBER  3
     GROSS AREA =    738.0 SF  ,WINDOW AREA =    255.0 SF
      DOOR AREA =     21.0 SF   NET AREA =    462.0 SF
       WINDOW COSTS--LABOR = $  58.09    MATERIALS = $   8.29
        DOOR COSTS--LABOR = $   4.78   MATERIALS = $   0.79
         U*A PRODUCTS--WALL =    29.1  WINDOWS =  237.1  DOORS =  19.5
          CRACK INFILTRATION PRODUCTS--WINDOWS = 1838.3  DOORS = 540.0
           SOLAR RADIATION PRODUCTS--WINDOWS =  216.8  DOORS =   17.9

              WALL NUMBER  4
     GROSS AREA =  1512.0 SF  ,WINDOW AREA =    150.0 SF
      DOOR AREA =     42.0 SF    NET AREA =   1320.0 SF
       WINDOW COSTS--LABOR = $  34.17    MATERIALS = $   5.63
        DOOR COSTS--LABOR = $    9.57   MATERIALS = $    1.58
         U*A PRODUCTS--WALL =    80.5  WINDOWS =  139.5  DOORS =  39.1
          CRACK INFILTRATION PRODUCTS--WINDOWS = 1660.5  DOORS = 702.0
           SOLAR RADIATION PRODUCTS--WINDOWS =  127.5  DOORS =  35.7
   TYPE ROOF LENGTH IN FEET, WIDTH IN FEET AND U FACTOR.
=108.2,71.67,.909
   TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE 1 ENCLOSURES, IF ANY--
      NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=1,900,323,.248,1000,0,.2278,.037025
   TYPE ROOF TEMPORARY ENCLOSURE DATA FOR TYPE 2 ENCLOSURES, IF ANY--
      NUMBER,LENGTH IN INCHES,WIDTH IN INCHES,U FACTOR,
      CRACK INFILTRATION FACTOR(CF/HR/FT OF PERIMETER),
      SOLAR RADIATION TRANSMISSION RATIO(BETWEEN 0. AND 1.0),
      INSTALLATION LABOR COST/SF,MATERIAL COST/SF.
=,,,,,,,,


     GROSS ROOF AREA =  7754.7 SF   TEMPORARY ENCLOSURES AREA(ROOF) =
       2018.8 SF   NET ROOF AREA =  5735.9 SF
       ROOF TEMPORARY ENCLOSURES COSTS--LABOR = $ 459.87   MATERIALS
        = $  65.61
         U*A PRODUCTS--ROOF = 5214.0  TEMPORARY ENCLOSURES=  500.6
          CRACK INFILTRATION PRODUCT = 3669.0
           SOLAR RADIATION PRODUCT =       0.
   TYPE FLOOR U FACTOR & FACTOR BASIS DESIGNATOR(1.=U BASED ON SOIL
      TEMPERATURE, 0.=U BASED ON OUTSIDE AIR TEMPERATURE)
=.036,


     FLOOR AREA =  7754.7 SF    U*A PRODUCT FOR FLOOR =  279.2
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   TYPE DESCRIPTION OF HEATING METHOD--UP TO 40 CHARACTERS
=STEAM HEATING SYSTEM PLUS "MASTER" HEATERS
   TYPE HEATING COST/1000 BTUS,AVERAGE INSIDE TEMPERATURE,AND MONTHLY
      COST OF MAINTAINING ENCLOSURES(AS PCT OF FIRST COST)
=.00434,40,1.04
   TEMPORARY HEATING WILL BE STEAM HEATING SYSTEM PLUS "MASTER" HEATE
         AT A COST OF $.00434 PER 1000 BTUS
              THE ASSUMED AVERAGE INSIDE TEMPERATURE IS 40.0 DEG F
                   THE ASSUMED COST OF MAINTAINING TEMPORARY ENCLOSURES
                        IS  1.0 PERCENT OF FIRST COST PER MONTH.
   TYPE NAME OF MONTH  1
=END JANUARY 1974
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=6,-32,35,,12,139,22,

   FOR END JANUARY 1974, WHICH HAS  6. DAYS, AND AVERAGE TEMPERATURES
      OF -32.0 (OUTSIDE),
          35.0 (SOIL), AND
          40.0 (INSIDE),
        THE TOTAL HEAT LOSS IS 111514691. BTUS,
        THE ESTIMATED HEATING COST IS $ 483.97
        AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $    6.74
        (BASED ON  1.04 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  1 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  2
=FEBRUARY 1974
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=28,-18,35,47,272,110452,342,

   FOR FEBRUARY 1974    , WHICH HAS 28. DAYS, AND AVERAGE TEMPERATURES
      OF -18.0 (OUTSIDE),
          35.0 (SOIL), AND
          47.0 (INSIDE),
        THE TOTAL HEAT LOSS IS 470663380. BTUS,
        THE ESTIMATED HEATING COST IS $2042.68
        AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $    6.74
        (BASED ON  1.04 PCT OF INITIAL INSTALLATION COST)
   IS MONTH  2 THE LAST MONTH
=NO
   TYPE NAME OF MONTH  3
=MARCH 1974
   TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
      AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
      (IF DIFFERENT FROM ORIGINAL INPUT),
      SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
      SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
      MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=31,8,35,55,500.5,806,2095,822,
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FOR MARCH 1974       , WHICH HAS 31. DAYS, AND AVERAGE TEMPERATURES
   OF   8.0 (OUTSIDE),
       35.0 (SOIL), AND
       55.5 (INSIDE),
     THE TOTAL HEAT LOSS IS 382256536. BTUS,
     THE ESTIMATED HEATING COST IS $1658.99
     AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $    6.74
     (BASED ON  1.04 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  3 THE LAST MONTH
=NO
  TYPE NAME OF MONTH  4
=1ST HALF APR 74
  TYPE NUMBER OF DAYS IN MONTH,AVERAGE OUTSIDE TEMPERATURE,
     AVERAGE SOIL TEMPERATURE,AVERAGE INSIDE TEMPERATURE
     (IF DIFFERENT FROM ORIGINAL INPUT),
     SOLAR RADIATION(BTU/SF)FOR THE MONTH ON HORIZONTAL,VERTICAL
     SOUTH-FACING AND VERTICAL EAST- OR WEST-FACING SURFACES,
     MAINTENANCE COST PERCENT(IF DIFFERENT FROM ORIGINAL INPUT).
=15,27,35,49,695,860,619,


  FOR 1ST HALF APR 74 , WHICH HAS 15. DAYS, AND AVERAGE TEMPERATURES
   OF  27.0 (OUTSIDE),
       35.0 (SOIL), AND
       49.0 (INSIDE),
     THE TOTAL HEAT LOSS IS  85859871. BTUS,
     THE ESTIMATED HEATING COST IS $ 372.63
     AND THE ESTIMATED ENCLOSURES MAINTENANCE COST IS $    6.74
     (BASED ON  1.04 PCT OF INITIAL INSTALLATION COST)
  IS MONTH  4 THE LAST MONTH
=YES
     TOTAL BTUS LOST ARE AS FOLLOWS--
          WALLS                          15953703.
          WINDOWS                        36651059.
          DOORS                           5701276.
          FLOOR                          27165376.
          ROOF                          507361292.
          ROOF ENCLOSURES                48717251.
          WINDOW CRACKS                 170228182.
          DOOR CRACKS                    60428268.
          ROOF ENCLOSURES CRACKS        178511526.
          SOLAR HEAT GAIN (MINUS)          423453.

               TOTAL                        1050294480.


     TOTAL ESTIMATED COSTS ARE AS FOLLOWS--
               TEMPORARY ENCLOSURES INSTALLATION       $  648.37
               HEATING                                 $ 4558.28
               TEMPORARY ENCLOSURES MAINTENANCE        $   26.97

                    TOTAL                                $ 5233.62

  DO YOU WISH TO REVISE SOME INPUT DATA
=NO
  VERY WELL. THE ANALYSIS TERMINATES HERE.   **
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